WHY METROSIL NON-LINEAR RESISTORS?

a product of M&I MATERIALS
INTRODUCTION

Metrosil provides surge protection to the largest power stations and electrical infrastructure projects in the world.

Metrosil offers a wide range of high voltage silicon carbide varistors that typically provide high energy surge protection for large-scale electrical equipment. Trusted by some of the largest power stations in the world, Metrosil can be found within many dams, including Grand Coulee, La Grande, Mica, Revelstoke, Itaipu, Xiangjiaba, Xiluodu and Three Gorges.

As high energy industries continue to develop, so too does the utility of our varistor discs.

Where there is a need for high energy absorption and superfast discharge, there is a need for Metrosil.
OUR HERITAGE

Dr. Ronald Sillars pioneered the development of Metrosil silicon carbide varistors in 1937.

Dr. Sillars studied the Natural Sciences Tripos at Cambridge before serving as a college apprentice at Metropolitan-Vickers between 1932 and 1934. With an obvious flair for electrical insulation, he soon established himself as an authority in the field, receiving a doctorate of philosophy in 1937 for his research at Oxford University into the causes of energy loss in dielectrics. Returning to Metropolitan-Vickers in 1937 as an Engineer, Dr. Sillars immediately began developing electrical insulating materials using silicon carbide. His findings marked a significant departure from existing understandings of resistant materials. Ohm's law saw current as directly proportional to voltage, however doubling the voltage applied to Dr. Sillars' products increased the current twentyfold. These non-linear resistors were named 'Metrosil', the name deriving from a combination of 'Metropolitan-Vickers' and 'silicon carbide'.

A VARIETY OF APPLICATIONS

As the world's power infrastructure developed, Dr. Sillars discovered further uses for Metrosil. Initially applied in lightning protection, Metrosil soon satisfied a variety of other applications, for example as a surge diverter for telephones, radar equipment and relays, whilst also protecting exciter discharge systems, transformer tap changers and rectifiers. During the Second World War, Metrosil was heavily utilised in the commutators and generators of naval vessels, with over 25,000 Metrosil units produced every week to satisfy demand.

Between 1954 and 1973, other notable achievements by Dr. Sillars include the invention of a multi-break circuit breaker and the publishing of 'Electrical Insulating Materials and their Application'; a book that is still used as a teaching aid to this day. In his later career, Dr. Sillars believed that it was no longer possible for one person to write authoritatively on the subject of electrical insulation. However, the rapidly accumulating knowledge and range of materials in the field were largely down to his research. In more recent times, Metrosil varistors have led to a variety of technical applications, including high impedance relay schemes, current transformers and electro-magnets.

M&I MATERIALS

Metrosil products are manufactured by M&I Materials at its headquarters in Manchester, UK. M&I Materials has a rich heritage in electrical insulation - the company grew out of the research division of GEC Alsthom and became an independently owned business in 1993. M&I Materials is focused on developing specialist materials for industry and science and is the driving force behind a portfolio of successful brands including MIDEL®, Wolfmet® and Apiezon®.
Our philosophy is simple - to provide unrivalled protection to those industries that work with and rely on high energy. We achieve this with three values that are at the heart of our business; Reliability, Expertise and Innovation. These values are represented by The Three Pillars:
Our strong heritage means that 'Metrosil' is often used as a generic term for a non-linear resistor. As a major power house in the 20th century, Metropolitan-Vickers was renowned for its industrial electrical equipment, which included generators, steam turbines, switchgear, transformers, electronics and railway traction equipment. Consequently, Metrosil varistors were specified into major flagship projects that paved the way for the efficient distribution of electricity. To this day our varistors remain in place within established power networks, and as a result, Protection Engineers in the 21st Century know that they can rely on our products to protect both existing assets and new-builds. Some of the world’s largest power stations put their trust in us.

**TRUSTED BY THE WORLD’S LARGEST POWER STATIONS**

- Three Gorges (China)
- Itaipu (Brazil/Paraguay)
- La Grande (Canada)
- Xiluodu (China)
- Guri (Venezuela)
- Grand Coulee (USA)
- Xiangjiaba (China)
- Nuozhadu (China)
EXPERTISE

Metrosil was borne out of the high-voltage department of Metropolitan-Vickers.

Supplied as silicon carbide discs in 1937, Metrosil marked a significant departure from existing understandings of resistant materials. It is widely believed that Metrosil was the first resistor to function as a Voltage Surge Diverter (VSD).

EXCELLENCE IN RESEARCH AND MANUFACTURE

To maintain our reputation, which is synonymous with excellence in research and manufacture, we never become complacent. Working alongside research centres and undertaking knowledge transfer partnerships with academic institutions ensures we remain leaders in our field. Following The Three Pillars, we excel in both expertise and innovation so that we provide the most reliable protection for high energy applications. Our customer service, technical and production teams work together to ensure that our customers receive optimal solutions that will deliver reliability. At Metrosil, we consider every aspect of customer service a priority. From fast response to an initial enquiry, to tight delivery schedules that meet customer project deadlines, our customer-focused processes are designed to ensure complete customer satisfaction from specification to installation.
INNOVATION

Metrosil is committed to manufacturing excellence and continued product development.

Developed directly with leading de-excitation system OEM’s and power industry experts, the Metrosil 8000 Series is a prime example of this commitment. Building on our successful 6000 Series, this modern assembly was designed specifically to accommodate advances in industry. Key benefits include:

- A high energy test facility to replicate generator discharge
- A protective bar to prevent accidental disc damage
- An anti-tamper device to ensure unit integrity
- Ergonomic handles to aid carrying and installation
- Robust, easy-access connection points
- A range of standard footprints for consistent installation
- A nameplate that permanently displays the assembly's specification details
- A high energy test certificate and 'pass' badge
- Event monitoring (available upon request)

All 8000 Series assemblies are tested to their full rated specification prior to dispatch via our one-of-a-kind High Energy Test Laboratory (HETL). HETL was commissioned to allow us to push the boundaries of testing. With HETL we can measure far more parameters than ever before and the confidence this gives our customers is invaluable.

INDUSTRY FIRSTS

Both the 8000 Series and HETL are industry firsts, and, in-line with our commitment to innovation, we intend to achieve another. We understand that high energy testing is just as valuable post-installation as it is during manufacture - therefore, we have developed a unique solution that will enable users of the 8000 Series to undertake in-situ monitoring. The Event Monitor (EM) has been designed to replace the 8000 Series' protective bar. By monitoring a point on each disc within an assembly, the EM allows the end-user to assess an 8000 Series assembly's performance relative to its initial HETL test results, which are programmed into the device and recorded at M&I Materials. Compatible with popular asset performance monitoring systems, the EM is therefore able to alert users when a surge event has occurred and give an indication to its high energy performance.
SILICON CARBIDE

Silicon Carbide (SiC) offers a number of attractive characteristics for high energy applications.

Originally produced by a high temperature electro-chemical reaction of sand and carbon, SiC has unique attributes. Mass produced as an abrasive since 1893, it was around 1907 when this semiconducting material was first utilised in electronic applications, for example within light-emitting diodes (LED’s) and detectors in radios. Metrosil non-linear resistors are sintered and pressed from pure SiC powder at M&I Materials’ factory. SiC provides the following benefits to our non-linear resistors:

- Superfast energy discharge
- High energy absorption

OVERVOLTAGE PROTECTION

Metrosil varistors are manufactured from a ceramic matrix of silicon carbide, carbon and clay. They are primarily used to protect large electrical networks by suppressing voltage surges. When an inductor is suddenly disconnected from its electrical supply, whether intentionally or due to a fault, the inductance of the coil acts to resist the change, and in doing so, creates a large inverse voltage across the terminals of the coil. If this voltage surge is not controlled, it will break-down the insulation of the wires within the coil. To prevent this, a resistive device, such as a Metrosil varistor, should be connected across the coil terminals to conduct the current leakage and drain stored energy away quickly. Specifying the correct varistor is essential. For example, if a resistance value is set too high, despite the rapid discharge time, the voltage across the coil could damage the insulation and electronic components within the system.

Our technical experts ensure that the correct solution is specified to meet the needs of our clients. The number of discs, disc diameter, disc thickness and type of grit will all be considered depending on the application. Once a specification is agreed, each assembly is built and tested on-site by HETL. The results are recorded within a certificate that confirms superfast discharge abilities. Before leaving our manufacturing plant, each and every varistor assembly will have proven its ability to limit voltage to a safe level whilst conducting current and discharging energy.

DISC MATCHING

Our manufacturing process and the non-linearity of our varistors makes high energy absorption possible. However, to improve absorption performance, we test each silicon carbide varistor disc prior to assembly so that we can ensure their electrical properties ‘match’. Disc matching is an extremely important part of our manufacturing process, as it ensures that each disc will evenly share the current and energy caused by an overvoltage. Discs matched by their electrical characteristics will provide high energy absorption in the most cost-effective and space-saving manner.
TYPICAL APPLICATIONS

Our SiC varistors are utilised within high impedance relay schemes, de-excitation systems and current transformer protection units.

Metrosil non-linear resistors are manufactured from a semi-conducting material based on silicon carbide, which has the distinctive property that its electrical resistance depends on the applied voltage. This enables them to act as an electrical 'safety valve' to protect equipment and insulation from the effects of overvoltages. The wide range of energy absorption ratings, current ratings and options in assembly type means that Metrosil is suitable as a surge protector for applications such as generator excitation systems, high impedance relays and current transformers.

GENERATOR EXCITATION SYSTEMS

An exciter in a synchronous generator is used to provide the DC supply to the electromagnetic field winding which is mounted on the rotor of the generator. In order to prevent damage being sustained to excitation systems during shut down, a suitable means to discharge the energy stored in the field coil must be available. Metrosil silicon carbide varistors have provided a reliable surge protection solution for exciter discharge applications for many years, being used by leading OEM's in worldwide power projects.

HIGH IMPEDANCE RELAYS

In some applications of high impedance relays, a Metrosil non-linear resistor is required to limit the secondary voltage to a safe level during a maximum internal fault condition. There is a range of Metrosil products to cover different relay setting voltages and fault currents for high impedance protection.

CURRENT TRANSFORMERS

Metrosil is used to limit the peak voltage developed by the current transformer (CT) under internal fault conditions to a value below the insulation level of the CT, relay and interconnecting leads. For open circuited CT's, i.e. during instrument removal, thermostatically controlled Current Transformer Protection Units (CTPU's) are used.
GENERATOR EXCITATION SYSTEMS

Metrosil Excitation Protection Units are trusted by industry leaders worldwide.

When faults occur, our de-excitation varistors ensure that disruption to power generation is kept to a minimum. Our de-excitation assemblies have been created as a direct response to both client and industry needs, and consequently have been developed directly with leading OEM's and industry experts. The ergonomics of the range have been optimised for ease of installation and future proofed to be compatible with industry developments.

- Large range of assemblies; 4000 Series, 6000 Series, 8000 Series and 9000 Series
- Optional performance monitoring system available for 8000 Series and 9000 Series
- Registered and patented designs
- High energy performance assured prior to installation
- High temperature insulation - NEMA approved
- Fully type tested - Metrosil ‘pass’ badge signifies quality
- All units shipped with individual high energy test certificate
- Ergonomic, stainless steel design for ease of installation

4000 SERIES

The 4000 Series is the most economical design from our range of de-excitation varistors. Specifically designed for the low de-excitation energy market, the modular 4000 Series is the perfect solution for smaller hydro generators.

6000 SERIES

The 6000 Series is our classic high energy varistor design. For many decades, these varistors have protected valuable assets in power generation stations.

8000 SERIES

The 8000 Series was created as a direct response to both client and industry needs. The 8000 Series, with its modern features, is suited to large applications.

9000 SERIES

The 9000 Series provides the highest energy density of any power varistor system available today. This assembly delivers a much more compact, space saving installation - assisted by unique, patented varistor tiles.
HIGH IMPEDANCE RELAYS

Traditional differential relay systems are used to protect individual pieces of plant.

The relay measures the difference between the current entering and leaving the protected area. If the current is not equal, then a secondary current flows through the relay system, causing it to trip after a finite time. Due to the presence of a stabilising resistor, should a high current flow through the system, then high voltages could occur. To prevent damage to the relay and CT, Relay Metrosils are utilised to clamp this overvoltage.

- Comprehensively 100% QC tested twice at electrical characterisation and final assembly
- Originally designed alongside OEM Protection Engineers for Areva (Alstom)
- Trusted, leading supplier - preferred supplier to all major Relay OEM’s
- Fully type tested designs
- Free design service
- Excellent safety record
- Many designs available ex-stock
- 4 weeks minimum lead time

METROSIL SELECTION

Correct Metrosil selection will ensure that protection is achieved with a leakage current low enough to have negligible effects on the accuracy of the relay at its maximum setting voltage.

Our Relay Metrosils are available as single disc, two disc or three disc assemblies.

The Metrosil chosen depends on the relay setting voltage and the maximum secondary internal fault current.

**Relays attached to Current Transformers with 1A rated Secondary Output**

Single disc Metrosils are suitable for a 1A CT with maximum internal secondary fault currents of up to 50A rms.

**Relays attached to Current Transformers with 5A rated Secondary Output**

For a 5A CT with maximum internal secondary fault currents of up to 150A rms, we recommend a Metrosil assembly with multiple discs connected in parallel.
CURRENT TRANSFORMERS

Preventative measures are strongly recommended by IEEE to protect CT's against open circuit conditions.

Open circuit conditions can occur inadvertently during routine maintenance of the burden. A Metrosil CTPU provides permanent protection against open circuits without the need for user intervention. It acts as a passive device while the burden is connected across the secondary winding, yet immediately clamps overvoltages during an open circuit condition – protecting the CT's winding insulation and core characteristics.

- Provides high impedance under normal operation
- Delivers low impedance during open circuit
- Available in both single and three pole varieties
- Every CTPU tested under open circuit conditions
- Voltage free analogue alarm contacts
- Compliance with IEEE C57.13 section 6.7.1
- Does not create electromagnetic interference
- Maintains characteristics over extended heat cycles and in high ambient temperatures

METROSIL SELECTION

There are 6 standard Metrosil CTPU types that can accommodate a wide range of burdens and operating conditions. Bespoke designs are also available upon request.

CTPU ENCLOSURES

Metrosil's range of pre-assembled CTPU Enclosures provide advanced shielding against the damaging effects of secondary side open circuits. Type tested and independently certified to IEC 61439 Parts 1 and 2, the units are available in adaptable configurations and flexible fitting options to suit specific application needs.
THE FUTURE

Metrosil will continue to provide unrivalled protection to those industries that work with and rely on high energy.

The diversity of Metrosil is illustrated by historical applications. Since manufacture, Metrosil has been utilised in:

- Lightning protection
- Commutators and naval vessel generators
- Telephones
- Radar equipment
- Relays
- Exciter discharge systems
- Transformer tap changers
- Rectifiers
- Lifting electro-magnets

Such applications all benefit from Metrosil's ability to absorb and discharge several MegaJoules (MJ) of energy. Typical values are:

- 1kJ – 2000kJ per assembly
- 1A – 8000A per assembly
- 600V – 1800V per assembly

As global industries continue to push technological boundaries, demanding higher energy and increased asset availability with reduced downtimes and lower maintenance costs, the desire to protect valuable assets has never been greater. Therefore, any application that creates or utilises high energy will benefit greatly from the superior protection that Metrosil provides.

In-line with The Three Pillars, our products will evolve to serve the power industry as it continues to develop and adapt to global changes. However, we will also seek to protect those industries that currently utilise other technologies to protect their assets from high energy.

Where there is a need for high energy absorption and superfast energy discharge, there is a need for Metrosil.
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