S&C Cypoxy® Insulators

Indoor and Outdoor Distribution | 4.8 kv through 34.5 kv

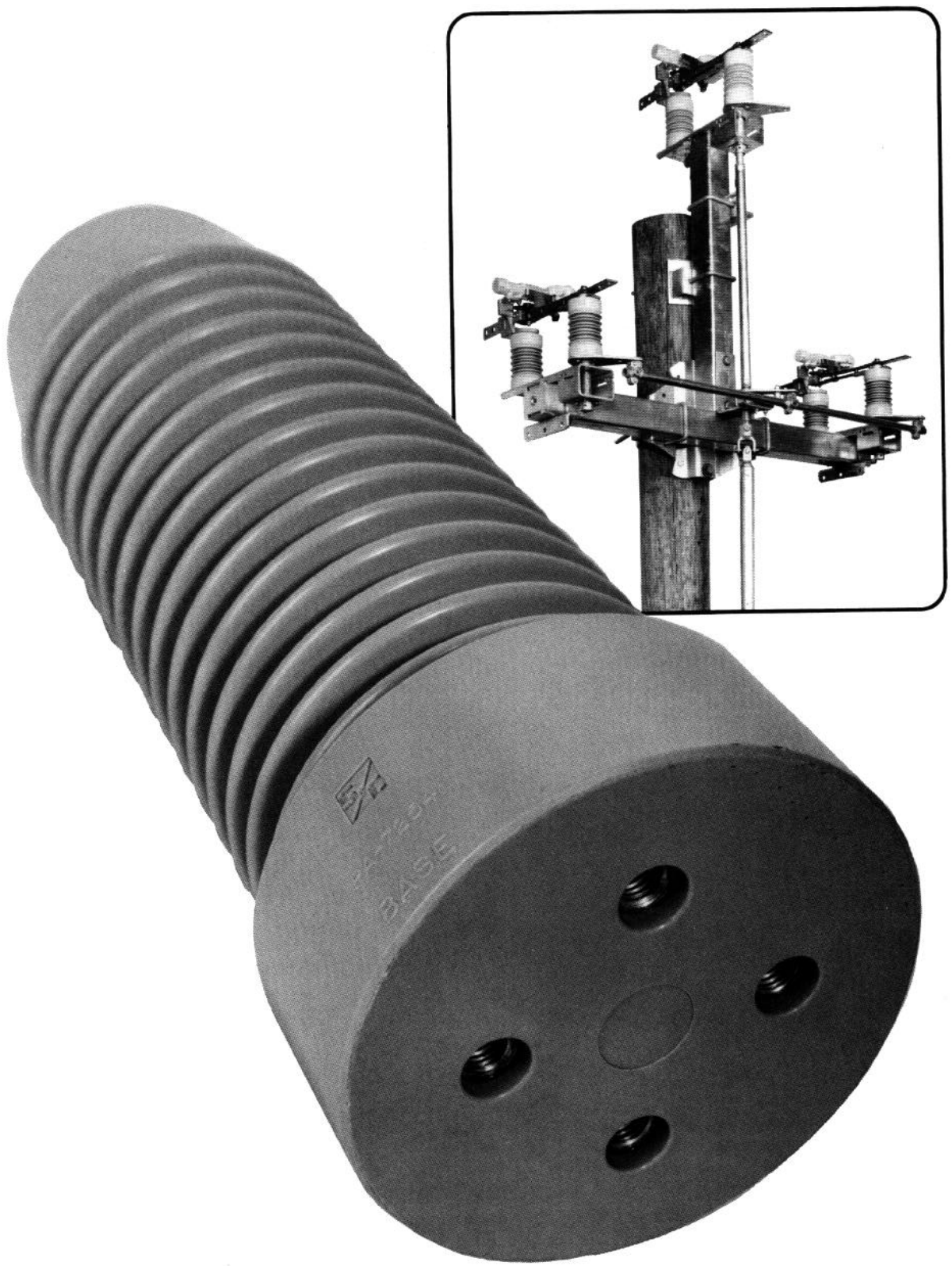

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PHOTO SHEET 911-700

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Introduction

Porcelain insulators traditionally have been the most widely applied insulators in electrical transmission and distribution systems. Although porcelain has served well in that capacity, it has several drawbacks which include brittleness, low impact strength, relatively high weight, and substantial limitations in manufacturing flexibility. In recent times, light-weight "non-porcelain" molded epoxy resins have gained increasingly wide usage in applications formerly provided with porcelain insulators.

The first application of molded epoxy resins for electrical insulation dates back to the 1950's when this new class of organic material was used in the manufacture of indoor switch and bus insulators. This first generation of organic insulator proved to be well suited for indoor applications, and clearly demonstrated the design and manufacturing versatility inherent to molded epoxy resins. However, outdoor usage of these insulators indicated a sensitivity to ultraviolet radiation in sunlight, as well as susceptibility to tracking in contaminated environments. As a consequence, the performance of the early epoxy resins in outdoor applications temporarily diminished the appeal of such insulators for outdoor use, and delayed the broad commercial acceptance of another improved class of epoxy resin that was being developed in the early 1960's.

The newer materials developed in the early 1960's were *cycloaliphatic* epoxy resins. Cycloaliphatic epoxy resins are organic compounds reflecting a ring-like molecular structure; hence, the term "cyclo" aliphatic. The cycloaliphatic epoxies (of which there are a number of different formulations) are comprised of saturated molecules that are inherently stable in the presence of agents that caused poor performance in the first-generation of "unsaturated" epoxy resins applied outdoors. The cycloaliphatic epoxy resins developed in the 1960's not only provide the advantages of lighter weight and superior manufacturing flexibility inherent to the earlier epoxy materials, but also improved resistance to weathering as now substantiated by more

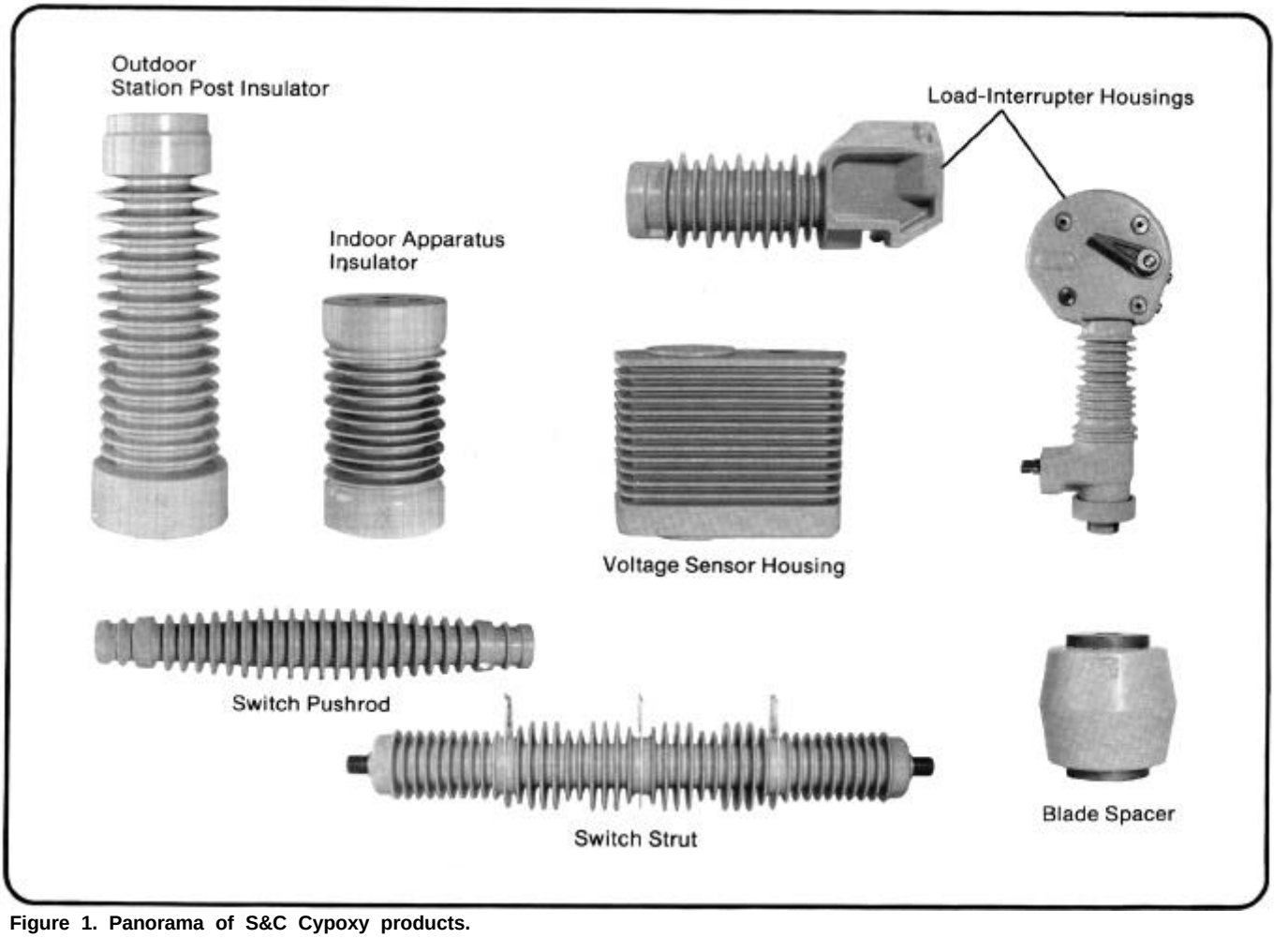


Figure 1. Panorama of S&C Cypoxy products.

than twenty years' successful performance in both indoor and outdoor environments.

S&C Cypoxy Insulators

S&C's Cypoxy insulators incorporate a *uniquely* formulated cycloaliphatic epoxy resin system especially tailored to provide the electrical and mechanical-strength characteristics detailed in industry standards for porcelain insulators, as well as unsurpassed performance in hostile outdoor environments.

S&C's experience with Cypoxy spans more than 15 years, and dates back to 1973 with the introduction of specialized housings, pushrods, and struts for use with distribution switches (see Figure 1). The ability to mold Cypoxy into intricate shapes with light weight and high strength has made Cypoxy an indispensable component of S&C's products. The light weight (low inertia) and high strength of Cypoxy components, moreover, has made it possible to develop compact space-saving switch designs not possible with conventional porcelain components.

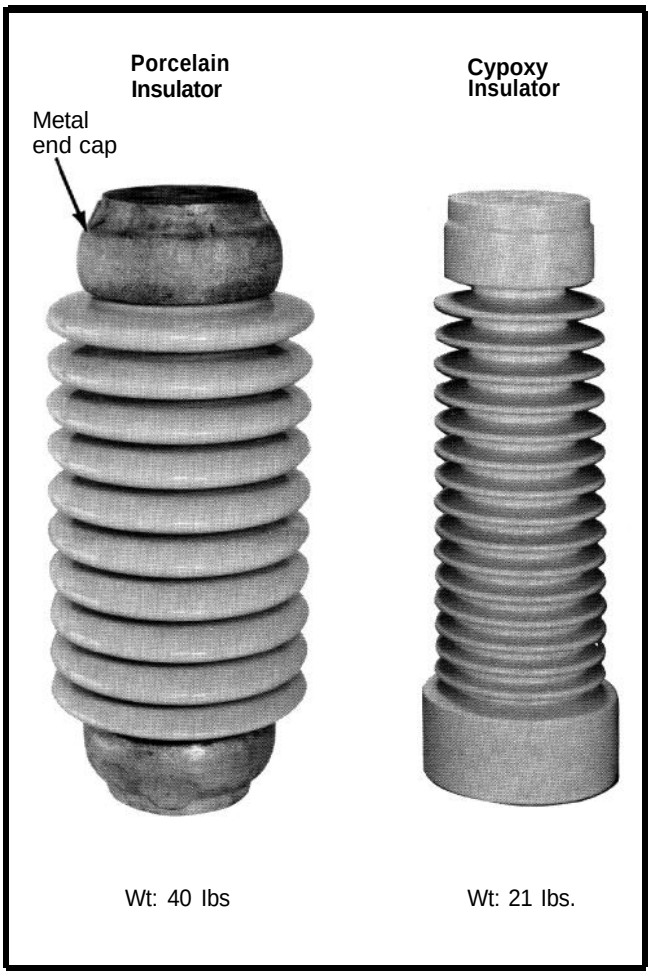


Figure 2. Comparison of Cypoxy Insulator to conventional porcelain Insulator (34.5 kv, 200 kv-BIL).

As S&c's Cypoxy-production facilities expanded, the specialized offering of Cypoxy components was broadened to include apparatus insulators developed for use with S&C's distribution switch and fuse products. The success of these insulators was such that, by 1978, Cypoxy insulators had completely supplanted porcelain insulators for all S&C indoor switches and fuses.

Cypoxy insulators have also been in wide use for *outdoor* products, with usage of Cypoxy pushrods for Alduti-Rupter® Switches dating back to 1976, and with the introduction of outdoor Cypoxy insulators to Loadbuster Disconnects® dating back to 1980. At this time, many thousands of Cypoxy insulators are in outdoor service with outstanding electrical and mechanical performance in all types of environments.

Most recently, a line of station post Cypoxy insulators in voltages of 15 kv, 25 kv, and 34.5 kv has been developed which meets or exceeds the electrical and mechanical-strength requirements established in ANSI Standard C29.9 (1983) for porcelain standard-strength station post insulators. Cypoxy station post insulators are designed as replacements for porcelain station post insulators, and are now available on a wide variety of S&C products rated through 34.5 kv. A panorama of S&C products available with Cypoxy insulators is included on pages 6 and 7.

Mechanical Characteristics

S&C Cypoxy insulators are manufactured using a process called pressure-gelation molding. In this process, cycloaliphatic epoxy compound-which includes a portion of silica and highly refined hydrated alumina-is introduced under carefully controlled conditions of pressure and temperature to precision-machined steel molds. The pressure and relatively low viscosity of the mixture permit formation of intricate contours that are not possible with fired-clay (porcelain) insulators. As a consequence, Cypoxy insulators can be manufactured with substantially more sheds for a given height than porcelain insulators (see Figure 2). The increased number of sheds contributes to the typically greater leakage distance of Cypoxy insulators.

Cypoxy insulators, in addition, include integral "cast-in-place" threaded aluminum inserts in lieu of metal end caps. As a consequence, Cypoxy insulators provide substantially greater dry arcing distance than porcelain insulators which include cemented steel end caps. And another important advantage of Cypoxy insulators is the light-weight design. Cypoxy insulators are typically on the order of one-half the weight of porcelain insulators, but with comparable mechanical-strength characteristics. Leakage distance and dry arcing values, plus weight and mechanical-strength values for Cypoxy

insulators are published in S&C Data Sheet 911-300.

S&C Cypoxy insulators are homogeneous, and neither require nor include a surface glaze. A glaze provides additional strength for porcelain insulators but, should it be damaged, can result in substantial loss of mechanical strength. Loss of glaze can also provide sites for deposition of contaminants on the surface of a porcelain insulator. Cypoxy insulators, being homogeneous, are not susceptible to surface "crazing" that is often associated with glazed materials. And should a Cypoxy insulator be chipped due to rough handling or vandalism, the exposed surface will provide the same performance characteristics of the original surface.

Electrical Characteristics

In addition to the light weight and compact design of Cypoxy insulators, these insulators are also nontracking, self-scouring, and nonweathering.

Nontracking performance of an insulator ensures that, under the stress of applied voltage, the insulator will not develop conductive tracks that promote leakage current and eventual loss of dielectric strength. Some formulations of organic epoxy resins are susceptible to material decomposition under voltage stress and dry-band arcing that can result in conductive carbonaceous tracking across the insulator surface. Over time, such tracks may branch and lengthen to a point that compromises the dielectric integrity of the insulator.

S&C Cypoxy insulators are nontracking because local pyrolysis of Cypoxy in the event of minute low-power arcing produces gaseous by-products such as carbon dioxide and water vapor that leave the surface virtually residue-free. Without track development, leakage current is kept to a minimum level that cannot affect the performance of the insulator. Cycloaliphatic epoxy resins have outstanding resistance to tracking, and S&C's unique formulation of cycloaliphatic epoxy has been specially tailored to provide the track-free performance of Cypoxy insulators. As shown in Figure 3, there is no evidence of tracking on a 15-kv class Cypoxy insulator continuously energized at nearly *1½ times* rating over a ten-year period.

Self-scouring performance is another characteristic of Cypoxy insulators that is directly attributable to the properties of the specially formulated Cypoxy material. Self-scouring performance ensures that the Cypoxy insulator will "clean" itself and thereby maintain full BIL insulation after interruption of an external power arc-due perhaps to lightning or bridging by an animal. Self-scouring performance is achieved because the high-temperature arc decomposes minute amounts of hydrated alumina used in the Cypoxy material-thereby liberating water of hydration as steam that scours the surface of the insulator in the path of the arc. As illustrated in Figure 4, a Cypoxy insulator subjected to a 10,000-ampere symmetrical power arc for approximately 10 cycles exhibits no structural damage following the arcing event. Moreover, the insulator material in the direct path of the arc has been cleaned by the self-scouring action of the Cypoxy. The discoloration in the border regions of the arc path is due to drift of vaporization products of the metal arc terminals and "flash wire" used to initiate the power arc. A porcelain insulator subjected to a similar power arc may suffer glaze damage and require post-arc cleanup or replacement.

The *nonweathering* characteristics of S&C Cypoxy insulators ensure that the insulators are completely resistant to ultraviolet radiation, and that they will not react with water or contaminants in the environment. As shown in Figure 3, the unweathered surface of a 15-kv class Cypoxy insulator unit with 10 years of continuous outdoor exposure in a midwestern climate, and continuously energized at 21 kv provides visual evidence of Cypoxy's outstanding performance in outdoor environments.

Laboratory and Field Test Experience

S&C Cypoxy insulators are exhaustively laboratory and field tested to meet electrical and mechanical-performance ratings under all types of environmental conditions. Ongoing test procedures in an outdoor seacoast test facility in California have substantiated superior resistance to weathering of S&C's Cypoxy insulators. After 10 years' exposure, S&C Cypoxy insulators are in excellent condition, with virtually no surface erosion or evidence of tracking. Identical test results have been observed with regard to Cypoxy insulators subjected to a severe midwestern environment over a ten-year period.

In addition to "real time" outdoor weathering tests, S&C has conducted accelerated-weathering tests at an outdoor desert test facility in Arizona. Testing at that facility includes an EMMAQUA test incorporating power-driven equatorially mounted solar reflectors to focus sunlight on test samples over extended periods. The test also includes a periodic water spray to further enhance the severity of the test. Cypoxy insulators have been subjected to this accelerated environmental test for the equivalent of 40 years' exposure in a climate

equivalent to that of Atlanta, Georgia. For more northern regions, the equivalent exposure is even longer. And, in terms of actual commercial experience for outdoor applications, S&C Cypoxy insulators now reflect more than a decade of successful application in thousands of installations worldwide.

Cypoxy insulators, in addition to exhaustive environmental testing, have been rigorously tested to confirm electrical ratings including impulse withstand (BIL) and low-frequency withstand (1 minute dry and 10 seconds wet). Extensive mechanical testing is also performed on a continuing basis to confirm cantilever-strength, tensile-strength, and compression-strength ratings of Cypoxy insulators. Thermal cycling tests, moreover, are conducted to confirm the ability of the insulator to withstand repetitive heating to ±120°F followed by cooling to –40°F.

In addition to testing of completed units, rigorous incoming inspections including infrared spectroscopy and liquid chromatography are employed to ensure that component materials used in the Cypoxy formulation meet the applicable S&C specifications.

In the 15 years S&C has been engaged in production of Cypoxy insulators more that 1½ million Cypoxy components have been shipped with S&C products, with unsurpassed performance in indoor and outdoor environments. Products offered with Cypoxy insulators are pictured on the following page.

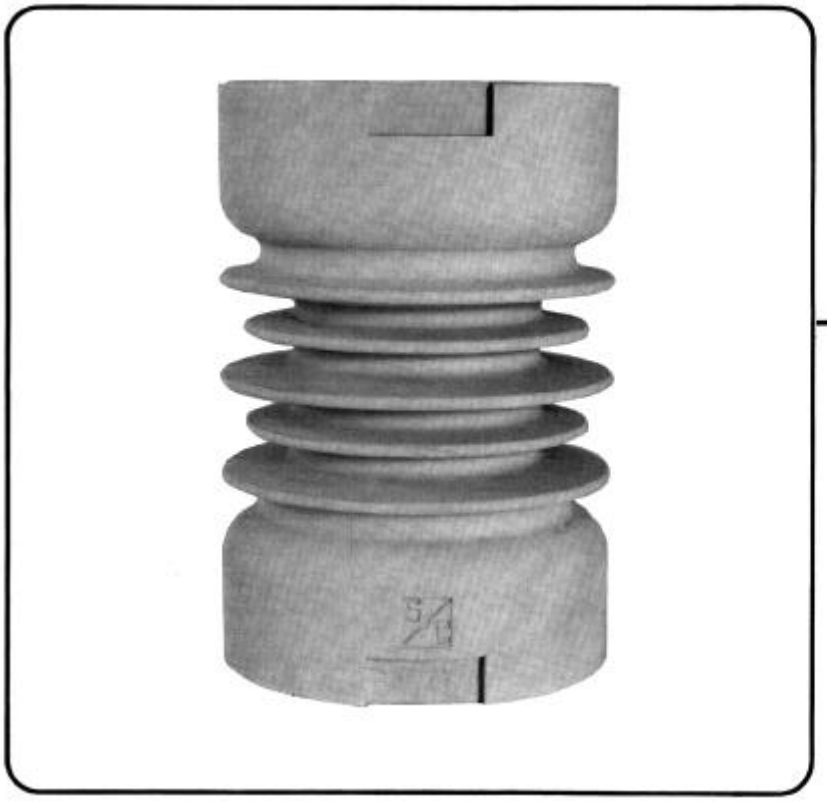


Figure 3. S&C 15-kv class Cypoxy Insulator, continuously energized at 21 kv, with approximately 10 years' exposure to outdoor environment.

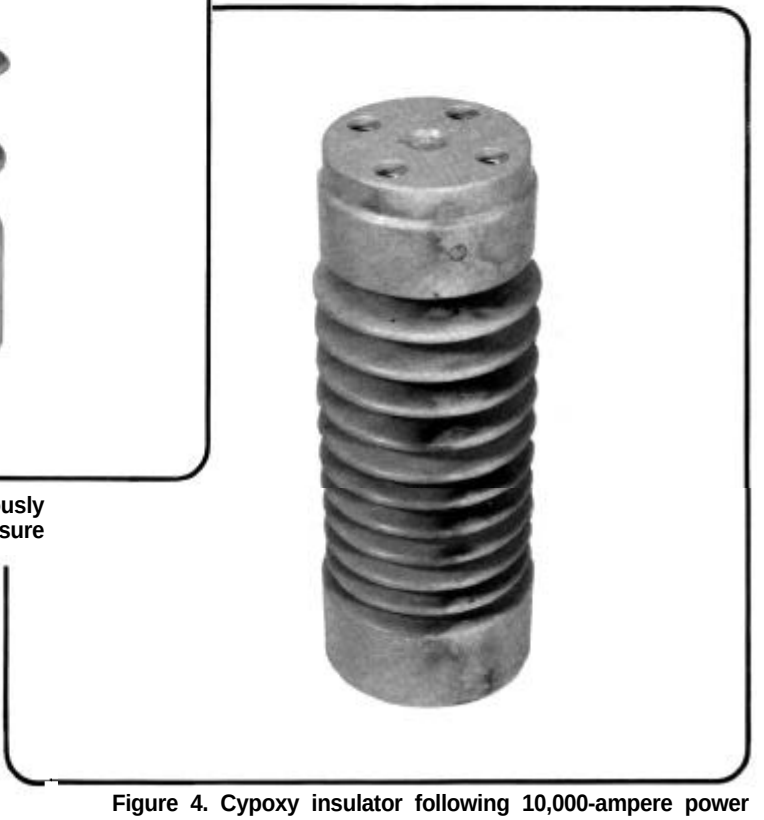
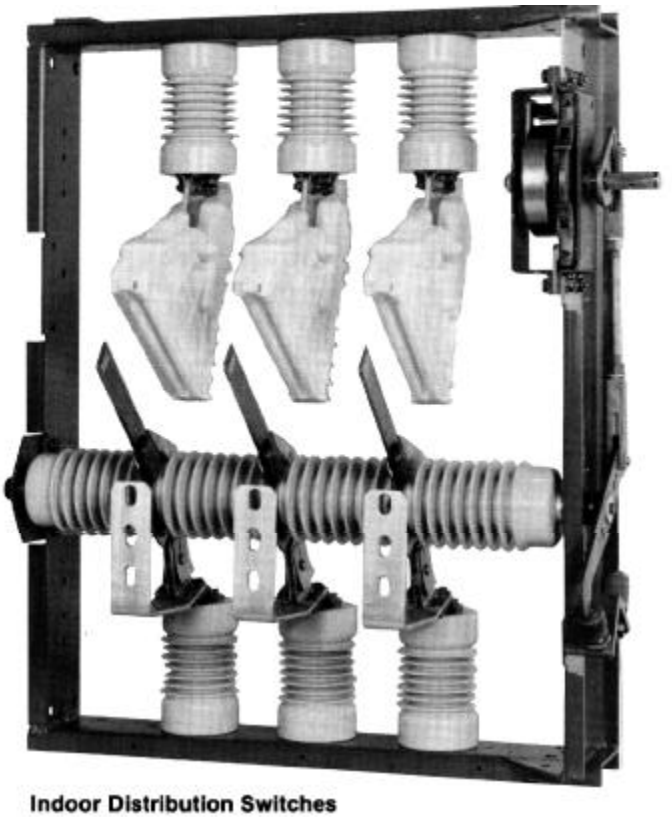


Figure 4. Cypoxy insulator following 10,000-ampere power arc.

Products Available with S&C Cypoxy Insulators

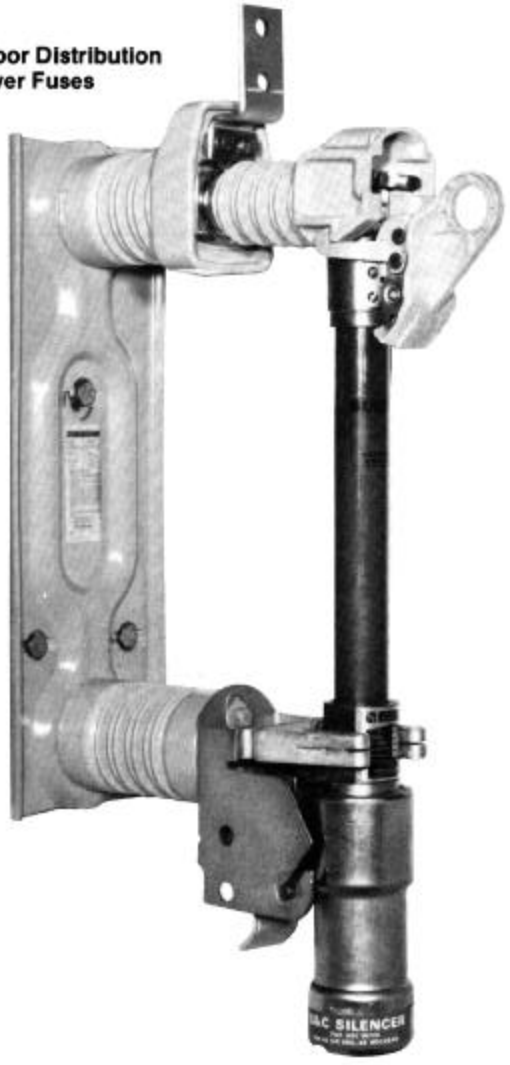
Cypoxy insulators are available in ratings of 4.8 kv through 34.5 kv and are offered with a broad selection of S&C products including: Resistored Power Fuses; Indoor and Outdoor SM Power Fuses; Station Style SMD-20 Power Fuses; Station Style XS Cutouts; Indoor and Outdoor Distribution Switches including Mini-Rupter® Switches, Alduti-Rupter Switches, and Omni-Rupter® Switches; Loadbuster Disconnects; Convertible Disconnects; Regulator Bypass Switches; and Recloser Bypass Disconnects. Following is a pictorial sampling of S&C products-both indoor and outdoor-that are available with Cypoxy insulators.

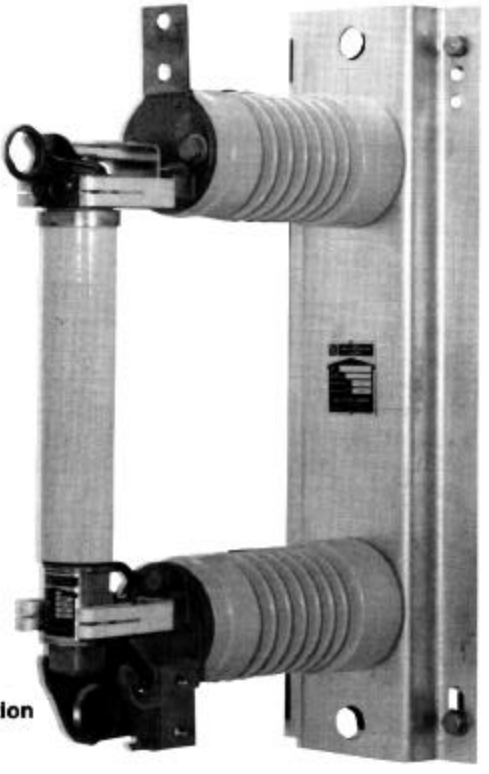
For additional information concerning Cypoxy insulators or products furnished with Cypoxy insulators, consult your nearest S&C Sales Office.



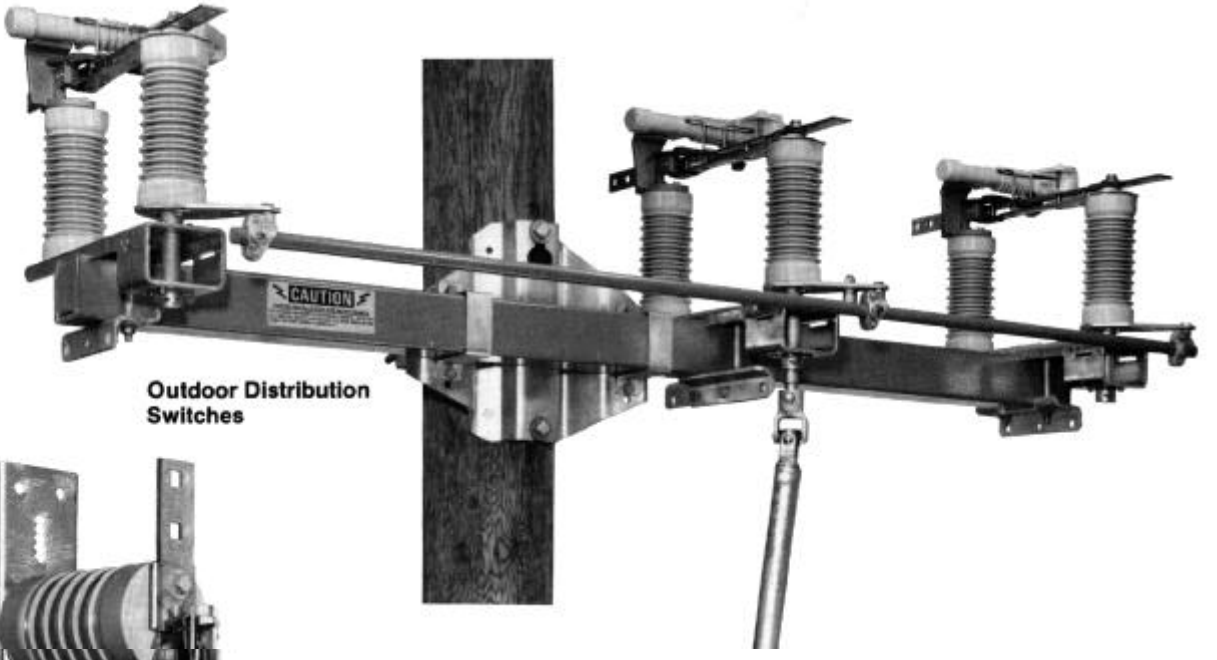
Indoor Distribution Switches

Indoor Distribution Power Fuses

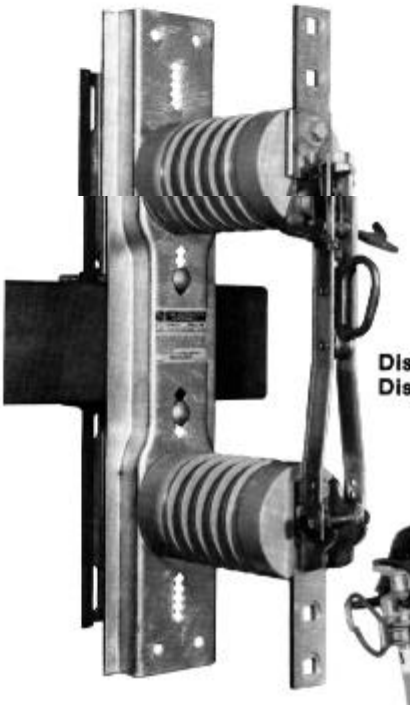




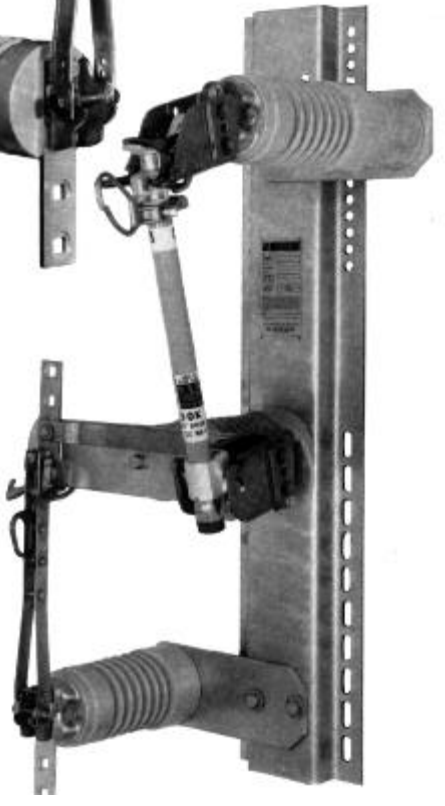
Outdoor Distribution Power Fuses



Outdoor Distribution Switches



Distribution Disconnects



Recloser Bypass Disconnects

The Cypoxy Advantage.. .

- **Light weight . . .** typically on the order of one-half the weight of comparable porcelain insulators
- **Greater dry arcing (strike) distance . . .** end-cap-free design provides greater strike distance relative to porcelain insulators with metal caps
- **Nontracking, self-scouring, nonweathering performance . . .** provides dependable insulation in all types of environments; stands up to high-power arcs without damage and without need for post-arc "cleanup." Won't track, even in contaminated environments . . . resistant to ultraviolet radiation
- **Superior toughness . . .** greater tolerance to physical impact; will not shatter due to thermal shock
- **Superior strength . . .** meets or exceeds mechanical-strength values for comparable porcelain insulators
- **Compact insulator designs . . .** made possible by manufacturing versatility inherent to molded epoxy resins
- **Economical . . .** products with Cypoxy insulators cost less, and save money-both initially and down the road-relative to products with porcelain insulators