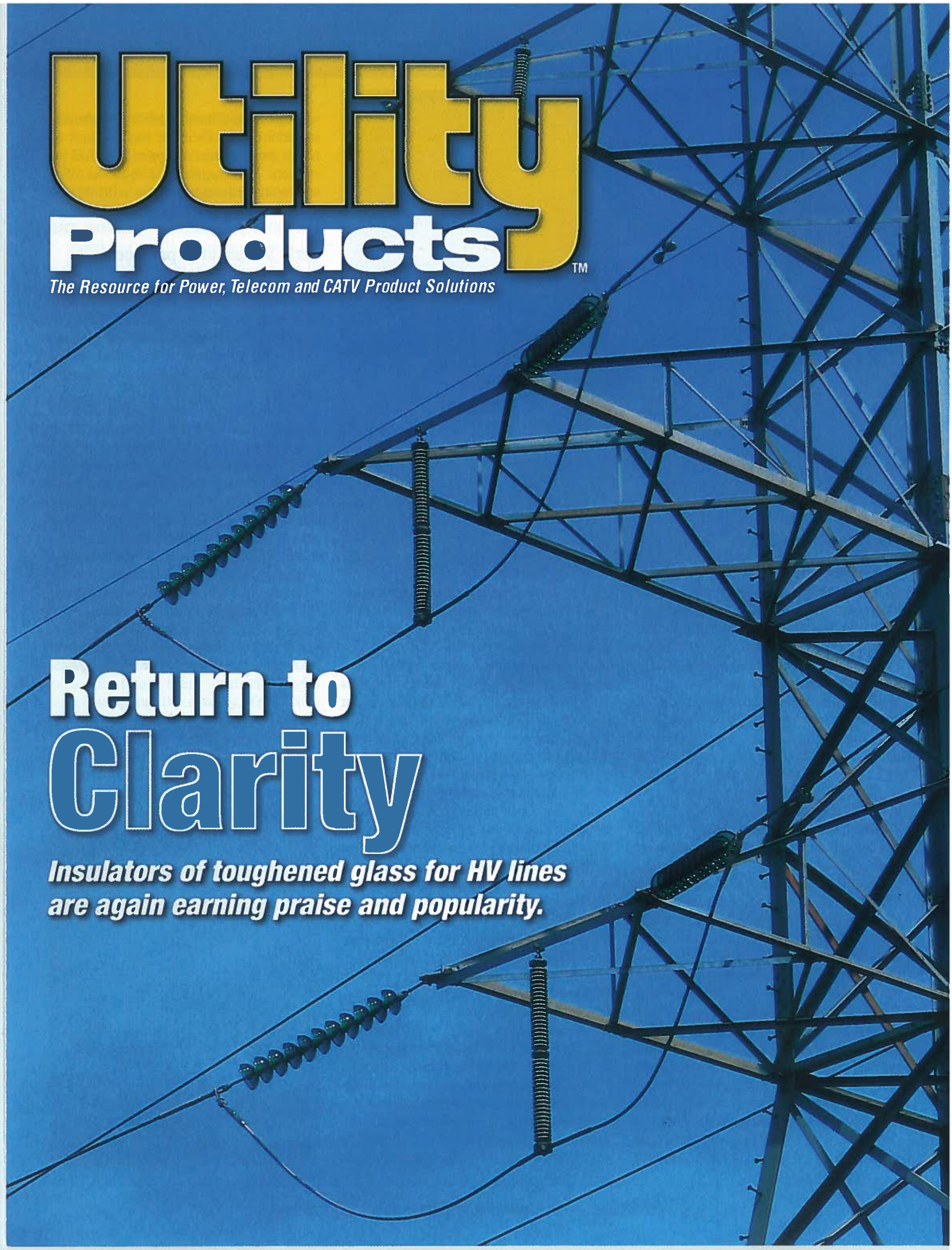
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Return to Clarity
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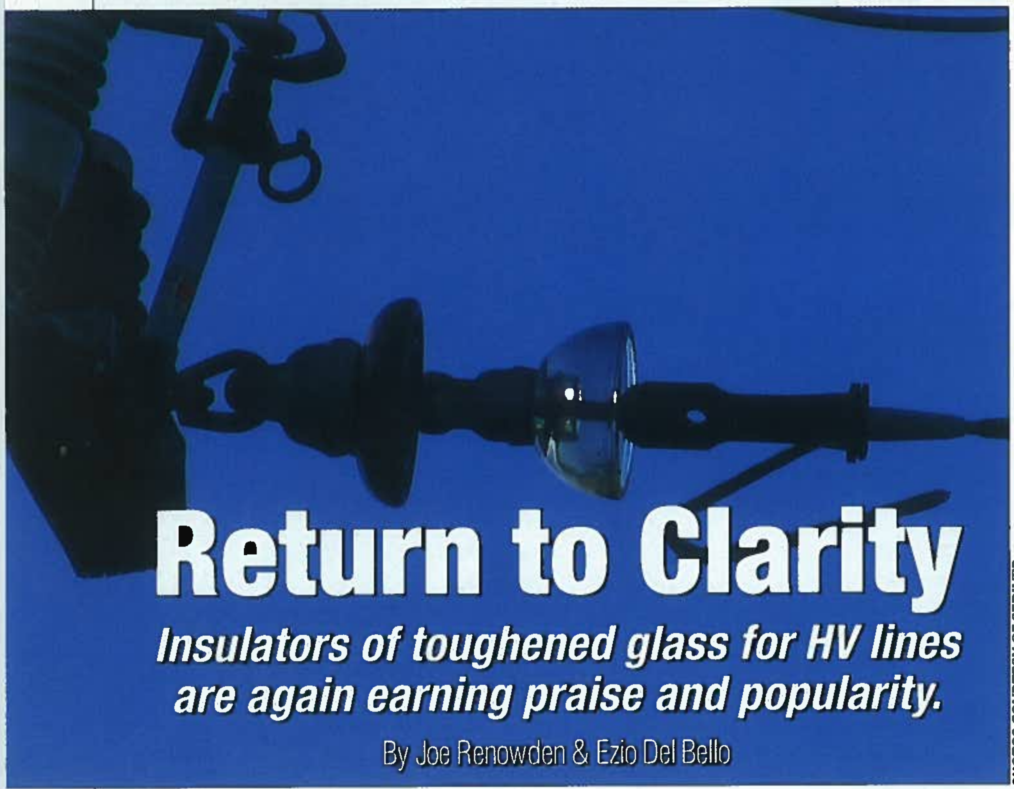

# Return to Clarity

## *Insulators of toughened glass for HV lines are again earning praise and popularity.*

By Joe Renowden & Ezio Del Bello

PHOTOS COURTESY OF SEDIVER.

It may be somewhat surprising that in the US market, which had seemingly converted to composite insulators, toughened glass (T/G) is making a comeback. The new trend is not so surprising if one takes a look at the history of toughened glass in North America since its introduction more than 40 years ago, and the peculiar circumstances which apparently led many utilities to forget about the unique benefits of T/G technology.

## A Brief History

Looking back at 1950, we find a world of porcelain insulators used on distribution and high voltage (HV) transmission line applications. Porcelain had been the dominant, exclusive technology for suspension insulators since the development of HV electric power lines starting at the beginning of that century. Porcelain technology kept pace with increasing strength requirements (demanded by ever higher voltage levels, span lengths and bundling of conductors) with continued developments in porcelain composition and strength. Those early, relatively weak quartz-porcelains were gradually improved and eventually alumina porcelains were developed for the higher strength applications.

Ordinary annealed glass could not meet the mechanical strength requirements needed for suspension insulators applications. So, for the entire first part of the 20th century, it was limited to low voltage applications; during that period a common application for annealed glass was for telegraph pins. Change in glass technology did not come gradually, as for porcelain. With the advent of the toughening process, the strength of ordinary annealed glass could suddenly be increased by a factor of 4-5, thereby exceeding that of porcelain. Thus, in one single leap, T/G technology overcame the mechanical strength disadvantage which for more than half a century had prevented utilities from making use of the unique electrical properties of pure amorphous glass.

The actual process of toughening was developed in the 1930s, but its application to complex 3-D shapes such as glass shells was industrially applied only after WW2. With the acquisition of the T/G patent by Sediver of France in the early 1950's, this technology quickly entered the HV insulator scene in Europe and immediately thereafter in North America and the rest of the world. Some European countries such as France and Italy quickly adopted the toughened glass on such a wide scale that it virtually replaced porcelain completely in suspension insulators applications. In Canada, the first HV lines were equipped with glass insulators in 1957, and already in 1959 one of the first 345kV lines in North America was equipped with T/G insulators. Introduction of T/G in the USA was achieved concurrently with that in Canada, and started to take hold in the early 1960's.

## Early Stages of Expansion (1960 – 1980)

Considering the typically conservative approach of utilities and the well-entrenched position of porcelain in the USA, the adoption of T/G was rather swift. The quick adoption of T/G was even more remarkable if one considers that in the 1960-1980 period there were several well established, reputable, local manufacturers of domestic porcelain. Well over five million glass insulators were installed in the first two decades and more than 10 million were installed by the early 1990s. This is the equivalent of approximately 50,000 miles of single circuit 138kV. The T/G insulator market was so promising that, starting in 1972, Sediver built manufacturing facilities in the USA, including local production of glass shells and an assembly plant.

What are perceived as the reasons for such rapid adoption of the new technology?

**EASE OF INSPECTION** - If the glass shell is there, it is electrically OK. If the shell is shattered, the electrical strength is reduced to a minimum but the insulator remains mechanically safe!

**ELECTRICAL AND MECHANICAL PERFORMANCE** - There is no risk of electrical puncture and no mechanical separation, so no risk of conductor drops.

**LONGEVITY** - Toughened glass does not age from micro crack propagation.

**SAFE HANDLING** - Shattered T/G always breaks in small pieces with no sharp edges, unlike porcelain which tends to break in razor sharp shards.

**LIGHT WEIGHT** - Thanks to the high strength of T/G, these insulators weigh up to one third less than equivalent porcelain insulators.

## The Rise of Polymer Composites (1970- 2003)

As T/G was taking a strong hold in North America and becoming more accepted as a modern replacement of traditional porcelain, the introduction of non-ceramic insulators (generally described as polymer composites) in the early 1970's changed the trend towards T/G in the USA. The change was rather imperceptible in the 1970's, but by the late 1980's a drastic reduction in use of T/G insulators occurred in the USA. Interestingly, in neighboring Canada, the introduction of polymer composite technology did not have the same effect and glass insulators there continued to be used throughout the country. The different market behavior between the two countries may be largely explained by two key factors:

Most Canadian Utilities are publicly owned and tend to have longer range outlook on their business. This tends to make them more conscious of life-cycle costs and, perhaps, more conservative in the adoption of new technologies.

The make-up of the US transmission system in the 69-230kV voltage range includes a much larger percentage of single pole configurations with line-post type insulators. Polymer composites were an ideal application to replace the porcelain versions that sometimes experienced cascading failures. The flexible behavior of composites relative to the brittle nature of porcelain was a most welcome improvement in line post technology.

In the US, the new composite technology was quickly adopted for compact line construction and line posts are today a significant portion of the composite insulator market. The promise of the new polymer composites market was so alluring that it was one of the main factors in the early closing down of some US porcelain manufacturing facilities. These were replaced, of course, by new factories designed to manufacture polymer composite insulators, and each US manufacturer came up with their own specific designs. Sediver, who was among the pioneers in polymer composite technology, also saw the opportunities of the emerging new market and built their own US plant in 1984 designed to produce their proprietary injection molded composite insulators.

## End of a Chapter for Ceramic Insulators

As the polymer market continued to expand and erode into the traditional porcelain market several U.S. manufacturers of porcelain started to abandon the older technology and focus exclusively on polymer composites. The number of local porcelain manufacturers gradually declined. Today, with the added pressures coming from globalization and low prices, there is virtually no domestic production of HV porcelain suspension insulators left in the USA.

Sediver was also focusing more and more energy on the emerging polymer composite market. So T/G gradually took the back seat to the point where by the early 1990s there was hardly any promotion or technical education done in the US on the T/G technology. We frequently meet young engineers who are quite knowledgeable about composites but unfamiliar with glass and even porcelain technology, even though there may be significant numbers of glass insulators, and even greater numbers of porcelain insulators on their own transmission systems. On the industrial side, toughened glass followed the trend set by porcelain manufacturers and in 1994 the Sediver US manufacturing facilities were closed down, while continuing to prosper internationally.

## Sediver Polymer Composite in the US

Throughout the 1980s and 1990s, polymer composites continued to gain market share, with corresponding reductions in both glass and porcelain suspension insulators. Then, in the 1990s came "downsizing" and "restructuring", and suddenly utilities in the US (and almost worldwide)

focused on minimizing costs. The price decrease in composites, which originally was industrially driven by increased production quantities and more efficient manufacturing, continued to be driven downwards by the new purchasing practices and increased competition. Paradoxically, the end result for Sediver was that it had to abandon the largest polymer composite market in the world by selling the US composite manufacturing facilities in 2002.

Today, looking back at recent history, the current reality is much better understood and the future of HV insulators in the USA can be seen taking a new path towards improved insulation systems. Ultimately, more and more utilities are realizing that continued technological improvement in polymer composite technology cannot be sustained in a climate of declining prices.

While utilities were installing more and more composites, the relative ease of handling and weight advantage of the new technology became widely appealing to construction crews. With time, actual performance criteria were sometimes sidestepped by secondary attributes such as light weight. In 2003, EPRI (Electric Power Research Institute) published a survey documenting the experience of 65 US utilities with the new composite technology. The survey clearly reveals that the overall experience to date of the total population of approximately four million composites in service in the USA is not at all reassuring. The number of brittle fracture failures (= a sudden break of the fiberglass rod) is rather high and some utilities have in fact decreased or stopped the use of composites. Concurrently, some utilities are finding that inspection costs are a serious financial burden when premature aging of polymer composites occurs. Such situations raise serious questions about the real cost advantage of composites, when life-cycle cost considerations enter the equation of total cost or "asset optimization". Finally, the ever-increasing loads on HV transmission systems and growing difficulties in obtaining pre-planned outages have revealed a serious draw-back to composite insulator usage on HV lines: the safety concerns in doing live-line work.

So now that long term service life and failures experience with polymer composites technology have revealed the possible problems with it, the stage is set for a more balanced evaluation of existing insulator technologies. The excitement and optimistic expectations that came with the introduction of a new and most promising technology have been superceded by the reality of their total performance characteristics. The time has come to take a fresh and clear look at a mature Toughened Glass Insulator technology. While there is no turning back from polymer composites in all compact line applications (line posts and braced line posts), the question as to which is the best technology to use for all suspension and dead-end applications needs to be asked again. Technology coexistence may be the way of the future for a while yet.

It has been reported on numerous occasions that the condition of the US transmission system is not in top shape and that many components have exceeded their expected useful life. Insulators are no exception and, with the increasing numbers of older porcelain insulators and now significant numbers of early generations of composites in need of replacement, utilities are already looking for options. One option is T/G insulators. Given the concern of many utilities with reliability performance, inspection costs, longevity and safety with live-line work, the writing on the wall points straight to T/G technology.

## Insulators with Built-In Detectors: A New Age for T/G Insulators

Toughened glass insulators have a proven track record and extremely high reliability. Most importantly, they come equipped with a natural built-in condition detector. The detector is not a physical device but rather a property inherent to the mechanical behavior of high-quality toughened glass. Toughened glass will not have hidden punctures nor hidden cracks and, when overstressed mechanically or electrically, will always reveal its condition by complete and unequivocal crumbling of the glass shell. This is without any significant reduction in mechanical strength (short and long term). That is the "detection" mechanism naturally embedded in each shell of high quality toughened glass.

No wonder the task of inspecting glass insulators is a simple visual inspection (with practically trivial costs associated with it) that requires no instruments or tower climbing.

For the above reason, any live-line work on T/G strings can be carried out safely. This fundamental difference in behavior between T/G insulators and alternative technologies makes them in fact extremely responsive to the most pressing current needs of US utilities. As knowledge and familiarity with the behavior and performance of T/G insulators are re-established in the US, there are many reasons to believe that the success story of the original introduction more than 40 years ago will be repeated. ❑