The Vinyl Institute

A Division of The Society of The Plastics Industry, Inc.

Electrical Materials Council

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VINYL

AN ENLIGHTENING LOOK AT THE 50-YEAR HISTORY OF THE WORLD'S LEADING ELECTRICAL MATERIAL

Introduction

Originally, it was specified for use as wire and cable insulation on military ships. Today, its applications range from house wiring to complex telecommunications circuitry; from electrical apparatus and cords to fiber optic and coaxial cable.

The product is vinyl, (PVC or polyvinyl chloride), the world's leading electrical material, which this year is celebrating its 50th or Golden Anniversary of safety, performance and industry preference in major electrical applications.

Some Early History

Although the monomer vinyl chloride was discovered as early as 1835 by Justus von Liebig at the University of Giessen, and reported as early as 1838 by the French chemist Regnault, flexible (or plasticized) vinyl was first developed for commercial use in the U.S. in the early 1930s as a replacement for molded rubber in shock absorber seals. Other early uses were for raincoats and shower curtains, trouser belts, wrist watch straps, flooring, wall covering, piping and upholstery.

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The first known electrical application occurred sometime in the late 1930s, when General Electric began manufacturing its Flamenol insulated appliance wire by extruding a flame-resistant insulation of plasticized vinyl over copper.

Vinyl first won broad acceptance in electrical applications in the early 1940s, however. At that time, World War II brought about shortages in natural rubber, and the fledgling vinyl industry, consisting primarily of BFGoodrich and Union Carbide, was called upon to supply critical electrical insulation products for the armed forces, particularly the U.S. Navy, that offered enhanced service life and safety.

Total production of vinyl resins and plasticizers increased phenomenally during the war years. But when the war ended, the industry was faced with the challenge of finding and developing civilian outlets for the substantial production of vinyl.

This was accomplished through work carried out on polymerization processes, compounding techniques, additive development and processing techniques. Extensive product application work further developed vinyl's performance properties of durability, versatility and greater resistance to ignition and flame spread than other natural and synthetic polymers.

Initial Applications

In electrical applications, the early 1940s saw the rapidly expanding use of vinyl as a superior replacement for both the textile braid covering and the rubber insulation in house wiring. Vinyl was recognized as far more lightweight, resilient, flexible and firesafe. Contractors appreciated that it didn't stick to conductors and

was faster and easier to install than rubber. And manufacturers appreciated that it required no vulcanization and could be processed faster and more easily.

Soon afterward, the mid-1940s saw the first use of vinyl in telephone system central office switchboard wire and cable. Vinyl replaced textiles, paper, lacquers and aluminum tape, whose major collective weakness had been moisture penetration which wreaked havoc with telephone transmissions. Additionally, the use of vinyl did away with the telephone industry's problem of textile lint accumulating in and fouling relays.

"The new (vinyl insulation and jacketing) has a number of advantages over earlier types," stated a technical paper at the time.* "It provides better moisture protection to the textile insulation on the conductors; this tends to smooth out variations of the electrical characteristics due to seasonal changes in humidity.

"The plastic jacket is tougher and more abrasion resistant," the paper continued. "It has no lint, as does the cotton cover; thus the likelihood of lint's causing open contacts on the switching apparatus is decreased. The covering is more easily stripped off at the ends for installation purposes, and it also improves the appearance of the cable."

The early 1950s saw applications of vinyl in telephone system subscriber station (customer) wiring and, not long after that, in handset cords. Then, by the end of the decade, because of its light weight, durability and superior resistance to the aging effects of sunlight and weather, vinyl was replacing neoprene and rubber in the "drop" wiring from telephone poles to subscriber stations in both commercial buildings and homes.

Plastic Covers for Switchboard Cables, D.R. Brobst, Bell Laboratories Record, 1950.

According to Bell Laboratory records at the time, at first the need for flexibility at low temperature for such outdoor applications was incompatible with the need for high insulation resistance. Through further research and development including adjustments in stabilizer and filler content, however, this difficulty was quickly overcome, with a tenfold increase in insulation resistance over initial vinyl formulations.

The mid-to-late-1950s saw the first uses of vinyl in industrial and commercial power cable. As the art of formulating vinyl grew into a science, the mid-1950s also saw the first applications of rigid vinyl electrical products, specifically the first underground electrical conduit. Ten years later, rigid vinyl was also replacing other impact-resistant molded materials in wiring guides and telephone handsets.

By the early 1970s, concrete-encased rigid vinyl conduit was being specified for use inside buildings, as were new flexible formulations for wire and cable. And by 1980, due to its superior fire performance properties, vinyl was replacing competitive products in both phone and data transmission riser cables, and two years after that in phone and data transmission plenum cables.

Today's Applications

Since the early 1980s, the vinyl industry has concentrated its resources on new products possessing enhanced chemical, physical and electrical properties. Within the recent past, for example, the industry has developed wire and cable compounds which have reduced heavy metal content, and compounds offering a new order of low smoke generation and low flame spread. New rigid compounds allow the manufacture of larger and more complex electrical terminal and outlet boxes and electronic equipment housings, such as computer terminals.

Today vinyl is formulated to meet a wide range of conditions and requirements. Manufacturers of electrical products can choose from over 300 UL listed vinyl compounds offering good dielectric strength, extrudability, colorability, flexibility and formulation versatility to meet a wide range of design requirements. These compounds offer additional performance properties including high resistance to cutting and crushing, resistance to moisture penetration, resistance to stiffening and oxidation after prolonged exposure to weather or heated conductors and resistance to UV degradation caused by exposure to sunlight or fluorescent lighting.

As a result, vinyl has emerged as the predominant material used in all wire and cable insulation and sheathing, commanding almost half of the total market. And, because market share continues to grow for rigid vinyl products like conduit, boxes and components, consumption of vinyl in electrical and electronic applications also continues to grow. Specifically, consumption in 1989 totalled 573 million pounds. This was up from 559 million pounds in 1988; 524 million pounds in 1987; and 478 million pounds in 1986.

Industry Issues

A primary concern about plastics of all types, particularly in commercial as well as in residential construction, has traditionally been fire performance. However, in rigid applications like conduit, the vinyl industry has consistently responded with products that are ignition-resistant and that will not sustain a flame once a heat source is removed.

In flexible applications such as wire and cable, the industry continues to pioneer the development of flame-retardant additives that provide even better fire properties than those required by minimum performance standards. Specifically, vinyl formulations are designed to release heat slowly, not to spread fire once a flame source has been removed and to produce smoke and corrosive combustion products as slowly as possible, without sacrificing vinyl's naturally high ignition resistance.

Another concern about plastics today relates to their impact on the environment. Vinyl resin suppliers began addressing this concern by exploring ways to recycle vinyl electrical materials more than a decade and a half ago.

Specifically, as early as 1975, Bell Labs, Western Electric and the Nassau Recycle Corporation, in cooperation with the vinyl industry, were already reclaiming vinyl from central office and customer premises scrap wire and cable, recycling it into sheathing for new cable. More recently, BFGoodrich just announced a novel venture to reclaim and reuse wire and cable scrap, processing the recovered vinyl into compounds to make traffic cones to U.S. Department of Transportation specifications. Meanwhile AT&T Bell Laboratories and Vermont Republic Industries are designing a manufacturing process which can be utilized by any electronics or communications company to recycle a vinyl product used in the shipping of integrated circuits.

The Next 50 Years

The size and vigor of the market for vinyl electrical materials today is the result of innovations in technology, process and product. It is also the result of the industry's efforts to participate in the code making process. Throughout the years, for example,

vinyl electrical products have repeatedly demonstrated their ability to meet the stringent requirements set by the National Electrical Code, the three model building codes and Underwriters' Laboratories for fire, physical and electrical performance.

Further, the size and vigor of the market for vinyl electrical materials today is the result of the industry's efforts to conduct research on industry-wide issues and to work with engineers, contractors and other specifiers to make certain vinyl electrical products are used safely, appropriately and to their full potential.

For example, as building environments have become considerably more complex than they were 50 years ago, and ensuring life safety has become a much more complicated process, the vinyl industry has supported fire hazard modeling to quantitatively measure the effects of burning vinyl as well as other materials in a fire environment. Among other things, such tests have shown that vinyl will not continue burning unless there is a powerful external source of heat, that when vinyl is consumed by other burning materials, it produces less heat and does so more slowly than most other materials and that the smoke produced by burning vinyl is within the same range as that of many other materials, but is produced more slowly.

The industry has sponsored other market studies, such as one that recently compared vinyl conduit with metallic tubing in four different construction applications in six major U.S. markets and found a savings of up to 33 cents per dollar in labor and installation costs for the vinyl system.

As tomorrow's electrical market continues to evolve, with new requirements to meet for voice and data transmission as well as for construction and all other applications, vinyl, one of the longest-established materials for electrical applications, appears uniquely positioned to remain one of the most popular.

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MILESTONE APPLICATIONS OF VINYL ELECTRICAL MATERIALS

1937	First recorded use of vinyl as wire insulation
1939	First use in house wiring
1941	First use aboard U.S. Navy ships
1946	First use in telephone system central office switchboards
1952	First use in telephone system subscriber stations
1954	First use in telephone cords
1955	First use in commercial and industrial power cable
1956	First rigid use outdoors in underground conduit
1957	First use in telephone system drop wiring
1967	First use in telephone system wiring guides, telephone sets
1971	First use of concrete-encased rigid conduit indoors
1975	First program to recycle vinyl wire and cable scrap
1980	First use in voice and data transmission riser cables
1982	First use in voice and data transmission plenum cables

* All dates are approximate, based on company records and the recollections of individuals directly involved in the applications at the time.