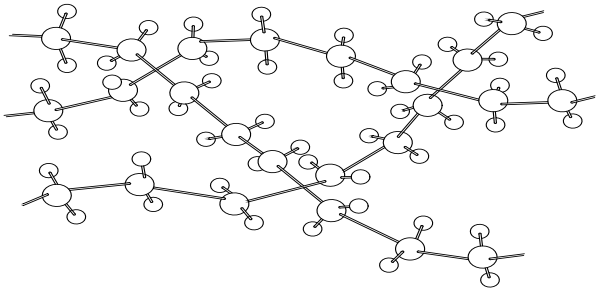
Irradiation Cross-Linking of Polymers for Wire and Cable

Irradiation Cross-Linking allows cost effective modification of a wide array of polymers to significantly improve their performance, allowing them to be used in harsh environments such as temperature extremes, fluids, mechanical stress and other challenging conditions.

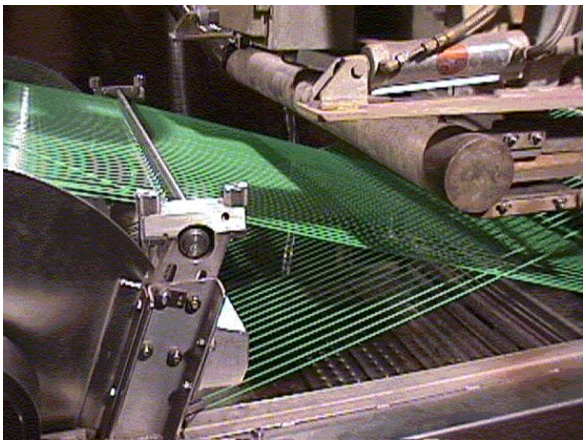
Thoughtful polymer formulation can also yield products with additional features such as flexibility, reduced diameters, longer life, stripping advantages, and other application-specific benefits.

Polymers are long chains of molecules. The simplest polymer and one commonly used in wire and cable is polyethylene which consists of a carbon and two hydrogen atoms. (i.e. CH_2) The figure below is a representation of polyethylene. The polymer chains intermesh in a random manner. However, as heat increases polyethylene chains soften, and eventually melt. Likewise, at low temperatures properties such as flexibility and embrittlement change as well. These are very undesirable effects for wires subjected to temperature extremes. Cross-linking improves the material performance, and adds many additional features.

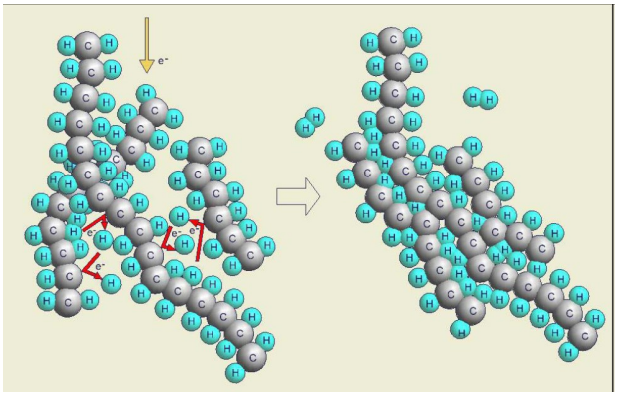


There are two primary methods used to crosslink wire. **Chemical** (CV / Continuous Vulcanization), and **Irradiation**. Chemical cross-linking relies on a chemically-induced reaction (heat and pressure) in the polymer that creates the cross-link bond. A significant drawback to the chemical process is residual peroxides in the polymer which impede dielectric and physical properties over time. Due to this, Chemical cross-linked wires are typically 125C and have limited 150C performance. There is also the risk of post-manufacture "on-reel" cross-linking which can be very problematic. Another concern with CV is that this technology often requires a paper separator between the conductor and the insulation to allow for free stripping.

Irradiation cross-linking provides an alternative method that does not require heat, pressure or steam, nor the chemical peroxides which impede the dielectric and physical properties of the material. Because irradiation cross-linking does not require heat and pressure that can force compound between the wire strands, the use of a paper separator is not necessary. Irradiation also allows for a wider range of materials to be used, which can produce superior products than chemical cross-linking.



Lead wire in a typical "figure-8" configuration under an irradiation beam.



The irradiation cross-linking process uses a stream of electrons produced from an electron accelerator. The electrons possess sufficient energy to remove a hydrogen atom from its position along the polymer chain which causes the reacted site to link to another such site to form a C-C cross-link as shown in this figure. The formation of a sufficient number of these cross-links locks many of the molecular bonds in place and results in transforming a thermoplastic material (one that melts) into a thermoset material (one that does not melt). This permanent molecular bond improves many performance aspects which are important in wire and cable.

Feature	Benefit
Higher temperature resistance	Performance in hot environments; Higher current carrying ability
No unreacted peroxide	More stable dielectric and physical properties
Thermoset, will not melt	Protects circuit if excessive heat occurs
Increased resistance to tensile, shear and compressive force	Thinner walls / reduced OD / Space savings Abrasion and cut through resistance
Water or superheated steam not used in Irradiation process	Eliminated risk of water ingress in conductor strands
Increased crush resistance	More robust / rugged performance
Increased chemical and oil resistance	Appropriate for use even when exposed to certain fluids
Insulation does not embed into conductor strands	No paper barrier; Easy to cut and strip
Color not affected by Irradiation	Colors stay true
Improved Flexibility (Product Specific)	Easier cable routing, Reduced human fatigue

Champlain Cable has been using irradiation technology for over 45 years and is a world leader of irradiation cross-linking in the wire and cable industry. Our eight irradiation units are capable of cross-linking wires ranging from 26awg to 700MCM, (0.14mm^2 to 350mm^2) and cables with diameters up to 1.5 inches (3.8 cm).

You can review specifications and learn more about our ingenuity at www.champcable.com