CROSSLINKING BY IRRADIATION (ELECTRON BEAM) TECHNOLOGY

Crosslinking is the process of creating strong bondings between the molecules in a material. It transforms the material from one that can melt and reshape (thermoplastic) to a rigid, non-melting state (thermoset). Crosslinking is used in cable manufacturing for several vital reasons. It significantly improves the cable's resistance to environmental factors, enhances electrical properties, and boosts flame resistance, ensuring the cables meet the high demands of modern technology and infrastructure, providing reliability, safety, and durability.

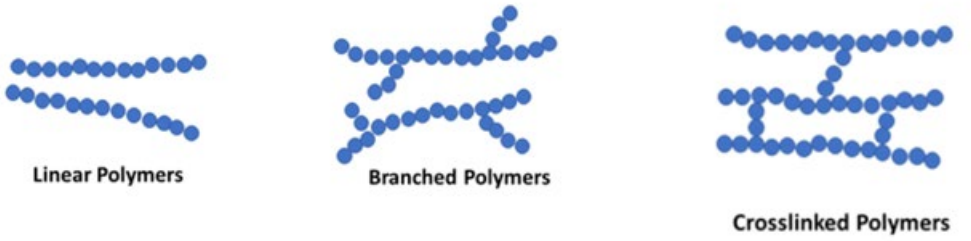

Figure 1: Types of polymers

CrossLinking (XL) Methods

Crosslinking can take place through both chemical and pyhsical (irradiation) processes.

Chemical crosslinking process must have the corresponding chemical crosslinking agent, that is, must have peroxide, sulphur or silane crosslinking agent; Irradiation crosslinking does not require chemical crosslinkers and is relatively efficient. Chemical crosslinking reaction must be carried out at the corresponding temperature, scientific and rigorous control of the extrusion temperature during the reaction process, otherwise in the early crosslinking is likely to occur coke, while the equipment also occupies a lot of space, consumes a lot of energy, production efficiency is not high, so it also limits the wide use of chemical crosslinking in wire and cable to a certain extent.

Irradiation (E-beam) crosslinking generally, does not need to be carried out under a range of high temperature and high pressure conditions, and the energy consumption required for irradiation crosslinking is also very low. The temperature rise of the polymer due to the absorption of beam energy is generally not greater than 70 ° C, and the metal hydroxide flame retardant added to the cable during the reaction process will not decompose due to high temperature during crosslinking. Therefore, irradiation(E-beam) crosslinking is generally very widely used for processing **flame-retardant cables**. Under normal circumstances, irradiation crosslinking can make the material obtain a high temperature resistance level, and there will be no residue after a series of processing, and long-term contact with acid usually does not appear swelling phenomenon. Irradiation(E-beam) crosslinking has a high production efficiency and is easier to control the crosslinking degree.

	CHEMICAL CROSSLINKING	**IRRADIATION CROSSLINKING**
XL Conditions	High Temperature	Room Temperature
Performance	Difficult to Control	Controllable & Uniformity
Application Range	Narrow	Wide
Product Efficiency	Low	High

SOLEN KABLO will utilize electron accelerator to achieve crosslinking through irradiation.

Electron beams are generated by heating a filament to activate electrons and then directing them through a vacuum tube onto a target material. As these high-speed electrons penetrate the material, they interact with its molecular structure, forming precise crosslinks between polymer chains. This process, known as e-beam crosslinking, enhances the material's properties compared to conventional methods, making it ideal for applications such as solar cables. Electron Beam Accelerator is a device to accelerate electrons in a tube to create scanned beams to give energy to cross link insulation or sheath compound. This technology like the cathode ray tube system of televisions.

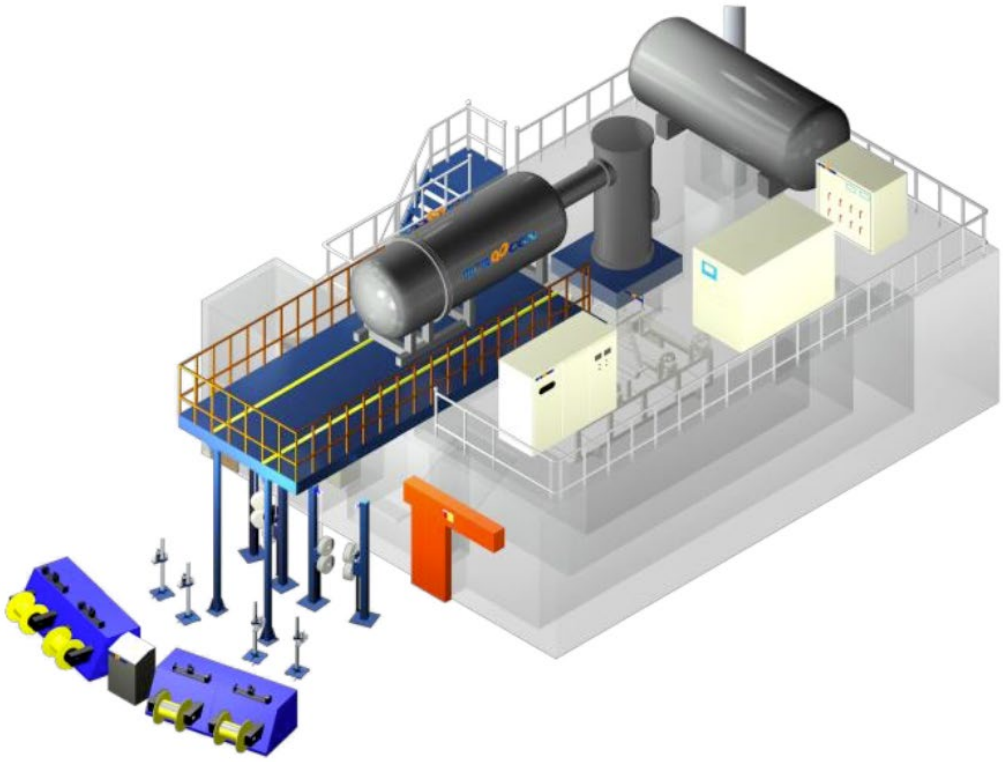

Figure 2: E-Beam Facility

Wire and cable due to the use of irradiation crosslinking process, should be designed according to product performance product structure and process route, like double-layer structure, three-layer structure, product shielding mode as the design content.

The cable industry always has been developing with the development of the materials and machinery industry. This development brought irradiation (E-beam) crosslinking technology to cable industry, having a significant effect on polymer materials like improving insulation resistance, voltage level, flame retardancy performance

E-BEAM CROSSLINKING ADVANTAGES & BENEFITS compared to CHEMICALLY CROSS-LINKING for XL - CABLES

- No Silane – chemical additives used gives **environmentally friendly characteristics.**
- **No more side defects and unwanted chemical reactions** because of usage of chemical additives e.g., Silane, Peroxide
- **Degree of crosslinking** can be easily controlled by the arranging amount of e-beam dose.
- Higher **current carrying** capacities and better **short circuit** characteristics.
- Higher **insulation resistance** allowing higher voltage level.
- Increased **Tensile** strength.
- More **Abrasion** resistant
- Higher **Melting Points** and **higher Thermal resistance.**
- Resistant to **Higher Temperature** that gives long life 30 years instead of 25 years.
- More resistant to **Chemicals, Oils, Acids and Fluids.**
- More **Flame Retardant** and very **less dripping** in case of fire.
- More resistant to **Mechanical Forces, Stress Cracks, Crush resistant**
- E-beam solution provides **much better insulation & jacketing crosslinking homogeneity.**
- Advantages for cable costing due to **less cost of insulation & sheath compound.**
- Short crosslinking - curing time allow better delivery time.

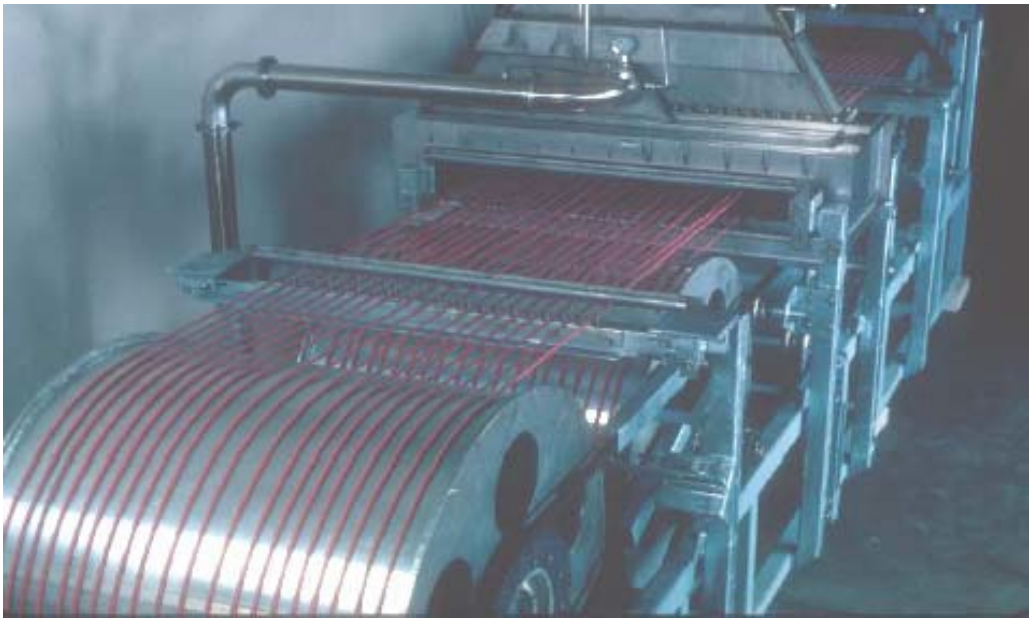

Figure 3: Cables under electron beam

SOLEN BEAM: THE NEWEST SOLEN CABLE BRAND

As **SOLEN KABLO**, we are taking a pioneering step in the sector by offering solar cables produced with E-Beam technology for the first time in Turkey. This ground-breaking technology provides our cables with enhanced durability, superior insulation properties and long-lasting performance. Our new and registered brand, **SOLEN BEAM**, is the symbol of quality and trust. Our cables bearing the SOLEN BEAM label are manufactured to provide maximum efficiency even in the most demanding conditions. You can choose the cables produced with our innovative technology with peace of mind and use them safely in your energy systems.

TÜRK PATENT

TÜRK PATENT VE MARKA KURUMU

MARKA TESCİL BELGESİ

No: 2024 105128 - Ticaret - Hizmet

solen beam

Marka Sahibi

SOLEN KABLO SANAYİ VE TİCARET ANONİM ŞİRKETİ

Mal / Hizmet Sınıfları

09

Bu marka, 6769 sayılı Sınai Mülkiyet Kanunu kapsamında,
16.08.2024 tarihinden itibaren 10 yıl süreyle korunmak üzere,
02.12.2024 tarihinde tescil edilmiştir.

Prof. Dr. M. Zeki DURAK
Başkan

Figure 4: SOLEN BEAM Trademark registration certificate

COMPARISONS OF SOLEN CABLE (CHEMICAL-SILANE) AND SOLEN BEAM (E-BEAM) CABLES

GENERAL INFORMATIONS	solen CABLE	solen beam
EN 50618 compliance	✓	✓
IEC 62930 compliance	✓	✓
TÜV RHEINLAND approval		✓
TÜV NORD approval	✓	
TÜV SÜD approval	✓	
IECEE CB approval		✓

KEY FATURES	solen CABLE	solen beam
REACH ve RoHS compliance	✓	✓
CPR Fire Performance Class (CE)	Dca	Dca
CPR Fire Performance (UKCA)	Dca	Dca
Expected Minimum Service Life	25 Years	**35 Years**
Crosslink Curing Time	2-4 week**	**N/A**
High Insulation Resistance	✓	
Higher Insulation Resistance		✓
High Current Carrying Capacity	✓	✓
High Short Circuit Performance		✓
AD8, Underwater Use Compatibility	✓	✓
AG2, Medium Impact Resistance Strength	✓	✓
Excellent Flexibility	✓	✓
Conductor-Insulation Good Stripping Performance	✓	✓
Abrasion Resistant	✓	✓
UV, Oil, Grease, and Ozone Resistant	✓	✓
Ammonia Resistant	✓	✓
Acid and Alkali Resistant	✓	✓
Compatibility for Direct Tough Embedded Use	✓*	✓*

(*) CONDITIONS OF USE DIRECTLY BURIED IN SOIL: Permission is granted for direct burial in soil, provided that the soil is free from harmful chemicals, solvents, rodents, termites, etc. Correct installation methods must be applied in accordance with VDE 0800-174 and VDE 0891-6 standards. Necessary precautions must be taken to prevent physical damage to the cables during installation. It is recommended that installation be carried out in pipes, ducts or concrete channels for maximum convenience.

(**) In cables produced by the silane (chemical) cross-linking method, the cross-linking process is completed naturally within 2 to 4 weeks, depending on the ambient temperature, or can be accelerated by applying high temperature and pressurised steam for a certain period of time. In cables produced with E-Beam technology, there is no curing time, this process is completed instantly and plastic materials are cross-linked directly. This results in a more stable and homogenous structure, despite the reduction in production time.

SOLEN KABLO (KİMYASAL-SİLAN) VE SOLEN BEAM (E-BEAM) KABLOLARI KARŞILAŞTIRMALARI

TECHNICAL CHARACTERISTICS	EN 50618 & IEC 62930 Requirements	solen CABLE	solen beam
Rated Voltage (AC)	1000/1000 V	1000/1000 V	1000/1000 V
Rated Voltage (DC)	1500 V	1500 V	1500 V
Max. Operating Voltage (AC)	1200 / 1200 V	1200 / 1200 V	1200 / 1200 V
Max. Operating Voltage (DC)	1800 V	1800 V	1800 V
Test Voltage	6,5 kV AC / 15 kV DC	6,5 kV AC / 15 kV DC	6,5 kV AC / 15 kV DC
Continuous Operating Temps.	-40°C / +90°C	-40°C / +90°C	-40°C / +90°C
Max. Conductor Temperature	+120°C	+120°C	**+125°C**
Max. Short Circuit Temp.	+250°C	+250°C	**+280°C**
Installation Temperatures	-25°C / +60°C	-25°C / +60°C	-25°C / +60°C
Min. Bending Radius	4D	4D	4D

EXAMPLES OF INCREASE IN CURRENT CARRYING CAPACITY

CROSS-SECTION (mm²)	solen CABLE (A)*	solen beam (A)	ADVANTAGE (%)
1x4 mm²	57	71	24%
1x6 mm²	72	90	25%
1x10 mm²	98	126	28%

(*) Current carrying capacities are calculated as single cable free in air at 30°C ambient temperature based on IEC 62930 standard

EXAMPLES OF INCREASE IN SHORT CIRCUIT CURRENT

CROSS-SECTION (mm²)	solen CABLE (kA)*	solen beam (kA)*	ADVANTAGE (%)
1x4 mm²	0,25	0,27	8%
1x6 mm²	0,37	0,41	10%
1x10 mm²	0,63	0,69	10%

(*) Short circuit currents are calculated for a duration of five seconds, with the maximum permissible short circuit current temperatures taken into account.