**LS SureClean™ Isolator Technology**

Reduce excessive ionic and particulate contamination and help cables maintain their integrity for a much longer life cycle. Your link to Technology.

When many medium voltage (MV) XLPE insulated cables were first installed in the late 1960’s, lack of cleanliness in the compound and cable manufacturing process, compromises in insulation, omitting jackets or jacket imperfections that accelerated corrosion meant cable was at a higher risk of experiencing moisture and voltage stress. As a result, cable failure rates have decreased significantly since the early 1980’s [7].

Today, compound manufacturers adhere to strict cleanliness standards through their process and packaging. Cable manufacturers also understand the need to create cable with insulation free of particulates, contamination and voids and with smooth interfaces between semiconducting screens and the insulation. Cable manufacturers have significantly improved their manufacturing practices through technologies such as clean rooms, closed material handling systems and true triple extrusion to maintain compound cleanliness through the process [8]. As a result cable life has been extended to an installed life of 30 or more years [9], [10]. Though failures due to contamination have been reduced to approximately 1% [12], the cost of replacing that cable is very high. Manufacturers continue to develop new materials and methods to increase the life of the cable.

![Graph showing cable failure rate](image)

**In-service Cable (Insulation) Failure Rate for Germany as a Function of the Year of Installation**

LS Cable & System has found the next evolution of cleanliness in material handling with the use of Isolator Technology during the transfer of compounds from manufacturing packaging to a closed material handling system.
Isolator technology has demonstrated its value as a proven improvement on existing technologies within industries where cleanliness standards are also critical such as pharmaceutical and food preparation [1], LS Cable & System has determined the use of isolator technology for the material handling of MV, HV and EHV cable provides the same advantages as other industries. These include greater cleanliness, fewer elimination of high contamination sources, unrestricted access, lower energy consumption, lower consumable costs and lower long term costs [5], [6]. The primary benefit of using isolator technology is to help create cable of higher quality that simply lasts longer.

To maintain compound cleanliness in a cable manufacturing plant the entire material handling process from receipt to extrusion must be designed for both efficiency and to eliminate introduction of environmental contaminants into the materials. Each system is designed for efficiency, cleanliness and cost effectiveness considering their product requirements and infrastructure constraints. Choosing the right system for your material will be contingent upon knowing various specifications like conveying velocities, conveying distance, operating pressures, and material characteristics [2], [4].

Raw materials are generally received by railcar and transferred to a silo or in Gaylord boxes or Super Sacks that can be stored in close proximity to the extrusion line. It is generally accepted that materials delivered from the supplier whether by railcar or in a Gaylord are equivalently clean [7]. For the purposes of this paper, super sacks will be considered along with bottom unloading Gaylord boxes. Super Sacks can sometimes have a larger volume than a Gaylord box however this difference is generally small. Each cable manufacturer must design their system balancing cost, quality, cleanliness and efficiency. LS Cables & System USA has designed a system that maximizes efficiency, minimizes installation cost, maximizes conveying quality and minimizes environmental contamination.

A railcar system is good for bulk delivery saving packaging costs. Gaylord packaging has advantages for storage and delivery closer to the extrusion line minimizing conveying distance and reducing environmental temperature effects. Differences lay in the method used to transfer the material to the extrusion line. Methods of conveying include gravity, dense phase, dilute phase, or vacuum [4], [8].

Each system has different advantages. Vacuum, dense and dilute phase conveying all transport the material using filtered air or gas under pressure from one point to another. Less air, and therefore less chance for contamination, is required for dense then dilute and finally vacuum conveying[4]. Gravity feed has a distinct advantage that outside air is not required to convey the material to the extruder and hence there is less risk to introduce environmental contamination.

While railcar delivery reduces packaging costs for the materials there is a significant increase in infrastructure cost including a rail spur, silo, and long conveying systems. In addition, transfer from the railcar to the conveying system
takes place outside or a specially built building where risk of environmental exposure such as dirt, dust, rain, and insects is significant. Silos typically contain a large volume of material. Since the silos are generally outside they are exposed to large temperature swings which can lead to a reduction in compound quality. Long conveyance lines increase the opportunity for additional contamination and streamers to form in the system.

Gaylord packaging can be in two forms; top or bottom unloading. Vacuum conveyance is typically used for top unloading Gaylord boxes. A steel wand is plunged into an open box of compound. The top of the box is often left open exposed to the room environment. Even if a cover is placed, it is difficult to seal to the wand and room air is sealed under the cover. To mitigate environmental exposure manufacturers may install clean rooms typically rated at ISO 7 (Class 10,000). This class of clean room will have 2,930 particles >= 5 μm per cubic meter. If the box is often left open, the compounds are left exposed to this environment from hours to days depending on production volumes and schedules.

<table>
<thead>
<tr>
<th>ISO classification number (N)</th>
<th>Maximum concentration limits (particulates/m³ of air) for particles equal to and larger than the considered sizes shown below (concentration limits are calculated in accordance with equation (1) in 3.2)</th>
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<tbody>
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NOTE: Uncertainties related to the measurement process require that concentration date with no more than three significant figures be used in determining the classification level.

Cable manufacturers of HV and EHV cable will typically use bottom unloading Gaylord boxes [8]. They have an advantage over top unloading as the liner from the box is attached directly to the material handling system and gravity is used to convey the compound either directly to the extrusion line or to hopper where it is conveyed to the extrusion line. Exposure to the environment is limited to the time it takes to disconnect the previous box and connect the new box (box change). This is usually done within a cleanroom environment that is typically ISO 7 (Class 10,000) however some manufacturers have installed ISO 6 (Class 1,000) clean rooms for this transfer and a few have installed isolator systems for the insulation only. These developments did mark an improvement in the process though it is typically reserved for HV cable [8].
Clean rooms achieve their cleanliness using a continuous circulation of air through a HEPA filtration system [6]. The flow is designed to be laminar in a downward direction to minimize the airborne particles. As the rate of circulation or exchanges per hour are increased the average number of particles decrease which improves the rating. A limitation of clean rooms is they are only as good as the individuals using them. Studies have shown up to 80% of the particulates in a clean room are carried in by humans [3]. Humans using the rooms must use new gowns, booties, hair nets, gloves and beard guards properly each time they enter the room. This is challenging to achieve in a manufacturing environment and creates additional monthly cost for the supplies.

The use of isolator technology, however, further minimizes the risk of contamination over existing industry practice. Isolator technology uses bottom unloading Gaylord boxes or Super Sacks placed on top of an isolator box. An air circulation system forces the isolator box air through a HEPA filter continuously [6]. The isolator box is much smaller in volume than a clean room area and closed which increases the exchange rate of the air enabling a much cleaner environment with the same air flow. Interactions with the compound box and material handling system are through special gloves designed for the isolator.

Workers do not enter the isolator box during the box change process thus eliminating the potential for human contamination in the environment. Material conveyance is then achieved through gravity to the extruder eliminating the need for the introduction of air into the conveyance system. Decreased contamination and the elimination of human contact further minimizes the risk of environmental contamination during a box change over existing industry practice.

LS Cables & System USA has designed and is utilizing a proprietary material handling system utilizing bottom unloading Gaylord boxes, isolator technology and a gravity conveyance system which LS Cables & System USA believes sets a new standard for clean material handling in the industry. Bottom unloading boxes ensures environmental exposure only occurs during the box change process which is completed within the isolator box. The isolator box has been certified as ISO 5 (Class 100). There are 100 times fewer particles than the standard ISO 7 (Class 10,000) clean room being used today.

During this process, all insulation pellets are transferred directly to the insulation extruder using gravity exclusively eliminating any environment air from being introduced into the system and the slow rate of feed eliminates any possibility of streamers. All potential sources of contamination have been eliminated or minimized with this system. By eliminating the need for clean room supplies and large conveying systems, long term cost is reduced below standard systems in the industry [6].

The material handling system was designed for use in the Tarboro, NC cable manufacturing facility. The facility was designed to house four CCV lines. The material handling system has a modular design and is simple to expand enabling it to supply compounds to all four CCV lines.
The system is currently being utilized to supply material for MV cables. At LS Cable & System USA, we have set a new cleanliness standard for material handling in the industry exceeding the industry standards used for EHV cable and it is being used for MV. The level of cleanliness provided by this system can only increase the value to our customers by assuring a long installed cable life.

References


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