Roll-Lock Automatic Inflation System

Technical Solution Brief | Greenhouse Curtain Heat Loss

The Problem with Single-Layer Curtains

A single layer of greenhouse polyethylene film has a low thermal resistance, with an R-value of approximately 0.85. As a result, significant heat loss occurs through the sidewall curtain, especially during periods of low ambient temperature. This rapid heat transfer can exceed the capacity of the heating system to maintain setpoints, leading to increased energy consumption, vertical temperature gradients within the crop canopy, and cold air infiltration along the greenhouse perimeter.

Industry Approaches to Sidewall Curtain Heat Loss and Their Limitations

Heat loss through sidewall curtains has been a longstanding challenge in greenhouse production. The most widely adopted solution has been the use of double-layer polyethylene film inflated with a small fan. This method increases the effective R-value from approximately 0.85 (single layer) to about 1.25. According to Virginia Cooperative Extension, this approach can reduce heating costs by roughly 50% compared to single-layer poly.

Conventional double-poly curtains have a practical limitation related to sealing. The standard practice is to secure the bottom edge using wiggle wire in a wire-lock channel. While effective for heat retention during the winter, this method effectively locks the curtain in the closed position for the duration of the heating season. When ventilation is required in spring, the wiggle wire must be removed, which is labor-intensive and increases the risk of damage to the poly film. Repeated removal and reinstallation over multiple seasons often leads to tears and accelerated wear, ultimately requiring premature replacement of the curtain material. In addition, removing the seal reduces heat retention whenever the curtain is opened or partially rolled.

Advancing Alternatives has addressed these limitations by adapting the established double-layer inflation technique to rolling sidewall curtains. The Roll-Lock system locks the curtain securely into a bottom channel when closed and inflated, yet allows the curtain to roll upward smoothly for ventilation when required. This provides improved thermal performance while preserving the operational flexibility of a traditional roll-up curtain.

Roll-Lock System Operation

The Roll-Lock system creates an inflated double-layer sidewall curtain that provides improved thermal performance while maintaining the operational flexibility of a traditional roll-up curtain. When closed, the curtain locks into a bottom channel and is inflated by a small blower. When ventilation is required, the curtain rolls upward, eliminating the need for seasonal removal of seals.

Roll-Bar Assembly. The system uses an aluminum roll bar that carries two layers of polyethylene film. The two layers are welded together at each end to create a sealed internal air cavity. A high-torque motor is mounted directly to the roll bar and drives the assembly vertically along a guide pipe.

Wind Rope Tracking. Exterior wind ropes are installed in a tensioned pattern across the face of the curtain. On straight sidewalls, the ropes form an “X” pattern; on curved sidewalls, they form an inverted “V”. In both configurations, the ropes hold the poly film firmly against the greenhouse structure. This prevents billowing from wind pressure, whether the curtain is fully closed and locked or in motion during opening or closing. The effect is particularly important on taller curtains (8–10 ft), where wind loads are greater.

End Pockets. End pockets are installed at each end of the greenhouse between the gable end and the second bow. These pockets are typically four feet wide and six to eight feet tall. They share the same inflation blower as the main curtain, with air supplied through jumper tubes. Because the end pockets and main curtain inflate simultaneously, they create a continuous, airtight seal at both ends of the sidewall run.

Operational Sequence

The Roll-Lock system is designed around two positional limit switches (one at each end of the curtain run) and a small inflation fan. Proper sequencing ensures the drive motor never works against internal air pressure and the fan does not operate while the curtain is open.

Closing and Seating. When the controller calls for heat retention, the motor drives the roll bar downward along the outside of the greenhouse wall. The bar travels four to eight inches past the Roll-Lock channel. Once the poly film is fully unspooled, continued motor rotation causes the bar to climb upward and seat firmly into the Roll-Lock bracket. This seating action is achieved through geometry alone and does not require motor reversal or a second command.

Switch Coordination. Two external limit switches manage the transition. The motor-side switch de-energizes the drive motor once the bar is fully seated in the bracket. The switch at the far end of the run simultaneously energizes the inflation fan. The switches are wired such that the fan operates only when the curtain is fully closed and locked in the channel.

Inflation and Seal. With the bar locked and the fan energized, air is delivered into the main curtain cavity and routed to the end pockets through flexible jumper hoses. As the dual-layer polyethylene inflates, internal pressure pushes the film outward against the wind ropes, creating a secure friction seal along the greenhouse structure.

Opening. When the controller calls for cooling or ventilation, the motor reverses direction. This motion immediately disengages the fan switch, stopping the inflation fan. Air between the two layers of poly is released as the curtain rolls upward.

Pressure Management The inflation fan remains off while the curtain is in motion. This maintains atmospheric pressure between the poly layers during both opening and closing, allowing the motor to operate without resistance from trapped air and ensuring smooth, consistent curtain movement.

Field Validation Using Infrared Thermography

To objectively compare thermal performance, infrared thermography was performed on both a conventional single-layer curtain and an inflated Roll-Lock curtain installed in the same greenhouse structure under similar ambient conditions. The thermal camera measures radiant energy emitted from the outer surface of the curtain. A warmer outer surface indicates greater heat transmission through the film, while a cooler surface demonstrates effective heat retention within the assembly.

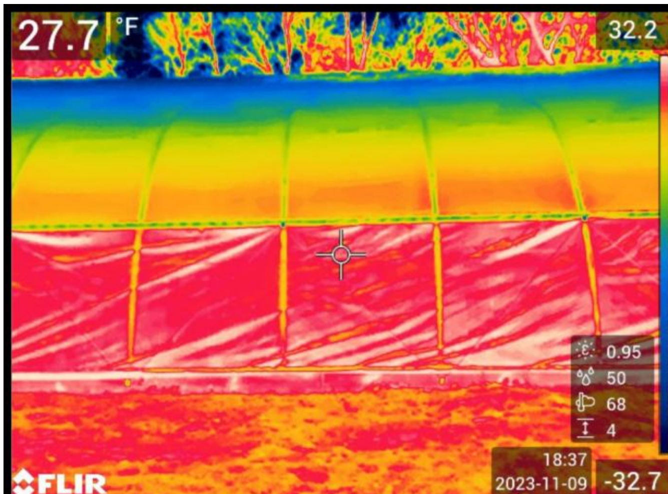

Figure 1: Single-Layer Curtain. The predominantly red coloration across the curtain face indicates surface temperatures approaching interior greenhouse air temperature. This demonstrates significant conductive heat loss.

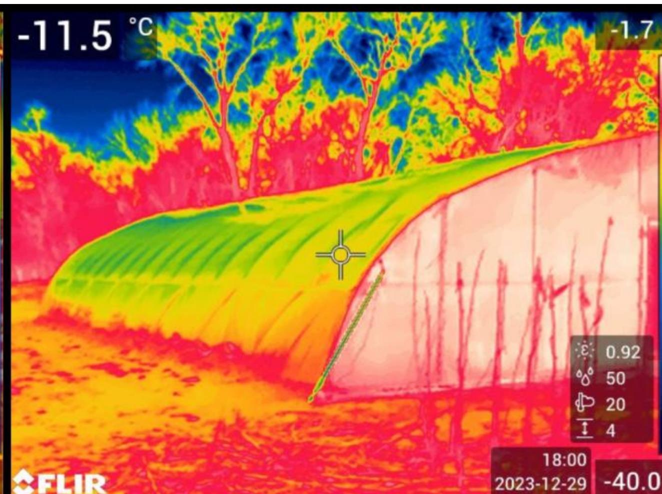

Figure 2: Inflated Roll-Lock Barrier. The curtain face registers primarily in green and yellow tones, indicating that the outer layer of polyethylene remains close to ambient temperature. The trapped air layer effectively retains heat.

Roll-Lock System Overview

The Roll-Lock system features a dual-layer polyethylene curtain welded at the ends and mounted on an aluminum roll bar. A high-torque motor drives the bar vertically along a guide pipe, while tensioned wind ropes in an X-pattern (straight sidewalls) or inverted V-pattern (curved sidewalls) prevent billowing. When closed, the curtain seats into a bottom locking bracket and is inflated by a small fan. Two external

limit switches coordinate operation so the fan runs only when the curtain is fully closed and locked. The system integrates with any environmental controller that provides a curtain output, including the AegisTEC and AegisTEC+.

The greatest energy savings occur in regions with longer and colder heating seasons, particularly north of the 35th parallel, where heating costs represent a larger share of annual operating expenses. Proper system sizing depends on greenhouse width, curtain run length, and the controller in use.