

**RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR)  
TC 10.9, Refrigeration Applications for Foods and Beverages**

**Title:**

Development of a Protocol to Accurately Determine the Base Refrigeration Load for Spiral and Straight Belt Freezers

**Research Category:** Food Processing and Preservation

**Research Classification:** Basic/Applied

**TC/TG Priority:** First

**Estimated Cost:** \$90,000

**Other Interested TC/TGs:** None

**Possible Co-Funding Organizations:**

International Association of Refrigerated Warehouses (IARW)

**Handbook Chapters to be Affected by Results of this Project:**

Refrigeration Handbook, Chapter 15

**State-of-the-Art (Background):**

Freezing is a widely used method of food preservation that slows the physical changes and chemical and microbiological activity that cause deterioration in foods. Reducing temperature slows molecular and microbial activity in food, thus extending its useful storage life.

Freezing systems can be grouped by their basic method of extracting heat from food products: Blast freezing (convection), Contact freezing (conduction), Cryogenic freezing (convection and/or conduction), and Cryomechanical freezing (convection and/or conduction).

Blast freezers use air as the heat transfer medium and depend on contact between the product and the air. Sophistication in airflow control and conveying techniques varies from crude blast freezing chambers to carefully controlled impingement-style freezers.

While batch freezing is still widely used, more sophisticated freezers allow integration of the freezing process into the production line. This integration, known as process-line freezing, has become essential for large-volume, high-quality, cost-effective operations. Continuous/process-line freezers include straight belt (two-stage, multipass) and spiral belt freezers.

Current versions of straight belt freezers use controlled vertical airflow, which forces cold air up through the product layer, thereby creating good contact with the product particles. Straight belt freezers are generally used with fruits, vegetables, French fried potatoes, cooked meat toppings (e.g., diced chicken), and cooked shrimp. The principle design is the two-stage belt freezer which consists of two mesh conveyor belts in series. The first belt initially precools or crust-freezes an outer layer or crust to condition the product before transferring it to the second belt for freezing and sensible cooling to  $-18^{\circ}\text{C}$  or below.

Multipass straight belt freezers are used for larger products with longer freezing times (up to 60 minutes) and higher capacity requirements (0.5 to 5.4 Mg/hr). Required floor space can be reduced by stacking belts above each other to form either (1) a single-feed/single-discharge multipass system (usually three passes) or (2) multiple single-pass systems.

Spiral belt freezers are advantageous for products with a long freezing time (general 10 minutes to 3 hours), and for products that require gentle handling during freezing. An endless conveyor belt that can be bent laterally is wrapped cylindrically, one tier below the last. This configuration requires minimal floor space for a relatively long belt. Air flow varies from little more than an open, un baffled spiral conveyor to flow through extensive baffling and high-pressure fans. Horizontal airflow is applied to spiral freezers by axial fans mounted along one side. The fans blow air horizontally across the spiral conveyor with minimal baffling limited to two portions of the spiral circumference. The rotation of the cage and belt produces a rotisserie effect. Another design splits the airflow so that the coldest air contacts the product both as it enters and as it leaves the freezer. Typical products frozen in spiral belt freezers include raw and cooked meat patties, fish fillets, chicken portions, pizza and a variety of packaged products.

### **Advancement of the State-of-the-Art (Justification):**

The refrigeration loads for spiral and straight belt freezers consist of two major categories: (1) the product refrigeration load which is 65% to 75% of the total refrigeration load, and (2) the base refrigeration load which is 25% to 35% of the total refrigeration load. The product refrigeration load is calculated from the frozen food production rate and the change in enthalpy of the food item during the freezing process. The base refrigeration load is the refrigeration required to overcome heat conduction through the walls of the freezer, air infiltration, belt cooling and internal loads resulting from motors, fans, and gear and bearing friction, as well as other sources. Estimates of this base refrigeration load by practitioners and manufacturers vary widely. Development of a protocol to accurately determine the base refrigeration load for spiral and straight belt freezers will provide a more realistic representation of the base refrigeration load and a more satisfactory freezer design for refrigeration engineers, designers, manufacturers, and end-users.

### **Justification and Value to ASHRAE:**

Development of a protocol to accurately determine the base refrigeration load for spiral and straight belt freezers will provide a more realistic representation of the base refrigeration load and a more satisfactory freezer design. Refrigeration engineers, designers, manufacturers, and end-users of food freezers will benefit from a protocol to accurately determine the base refrigeration load for spiral and straight belt freezers. These individuals constitute a significant constituent group within ASHRAE.

### **Objective:**

The objective of this project is to develop a protocol to accurately determine the base refrigeration load for spiral and straight belt freezers.