# Cryogenic vs. Mechanical Food Freezing

Food freezing can be accomplished by either mechanical or cryogenic freezing. In each case, the freezing process, and the results are fundamentally different.

While mechanical freezing systems are generally characterized by large capital investment, significant energy and preventive maintenance costs, and high usage of plant space, the cryogenic freezing is often characterized by high cryogen (liquid nitrogen or carbon dioxide) cost.

The selection of optimal freezing method is not simple, and cannot be justified on "cost to freeze per pound" alone. In theory, either freezing method can be applied to any type of food. In practice, however, the food processor must carefully balance the capital cost, operating cost, regulatory compliance cost, and product quality, to determine the best method for the company and the consumer.

## Food Freezing Options

| | Cryogenic Freezing | Mechanical Freezing |
|---|---|---|
| Investment Costs | Lower cost of capital equipment and simpler, inexpensive installation. | Higher cost of capital equipment and complex and costly installation. |
| Operating Costs | Higher energy cost with liquid nitrogen or carbon dioxide as energy source. | Generally lower energy cost. |
| Maintenance Costs | Low:<br>• High uptime<br>• Low maintenance requirements<br>• Reduced cleaning requirements | High:<br>• All parts of a mechanical refrigeration system consisting of three major pieces: high horse-power compressor, condenser, evaporator, and refrigerant storage must be inspected annually.<br>• Ammonia refrigeration systems with 10,000 pounds or more of ammonia are a covered process subject to the requirements of the OSHA Process Safety Management Standard (PSM) 1910.119. |
| Freezing Temperatures | Typically, -160°F or lower for Liquid $N_2$ and -80°F for liquid $CO_2$. | Typically -30°F |
| Food Quality | Rapid freezing reduces dehydration loss to less than 1%, thus preserving texture and flavor.<br><br>Product does not stick to belt. | Slower freezing, up to 3 to 4 times longer than cryogenic freezing, can result in surface dehydration and weight loss and does not allow the successful preparation of Individually Quick Frozen (IQF) products.<br><br>Product tends to stick to belt. |
| Environmental Considerations | Environmentally friendly way of freezing food. | Ammonia is a great refrigerant but it is highly toxic. |

MATHESON
The Gas Professionals

| | Cryogenic Freezing | Mechanical Freezing |
|---|---|---|
| Regulatory Compliance | Easily meets FDA and OSHA regulatory requirements. | The EPA, acting under the Clean Air Act, requires facilities to submit Risk Management Plans (RMPs) if they use, produce or store a threshold quantity of a regulated substance.<br><br>Implementation of the OHSA PSMs and EPA RMP programs is often beyond the capabilities of an average size food processor.<br><br>Near-term regulatory pressures and cost impact to food processors are impossible to predict. There are strong indications that OSHA is considering the development of a National Emphasis Program (NEP) for ammonia and PSM. This would mean increased scrutiny on facilities using ammonia refrigeration. |
| Plant Space Usage | Lower freezing temperatures mean quicker freezing. The dwell time in the freezer is less so equipment can be smaller and deliver same throughput as larger mechanical systems. | Higher freezing temperatures mean slower freezing, and equipment is larger due to reliance on cold air circulation through the belt, which limits the belt loading to 80% for effective operation.<br><br>Longer dwell times, typically 3 to 4 times longer than cryogenic, mean the equipment has to be proportionally larger to achieve the same throughput. |
| Operational Flexibility | Can easily be adopted or expanded for different production lines.<br><br>Dwell time can be changed from several minutes to several hours, and freezer temperature from -20°F to -160°F or lower. | Not suitable for product changes. Changing the product type, or changing the application (freezing, surface hardening, or chilling) may require a major modification. |



TB415 09/2021

MATHESON
The Gas Professionals

Printed in USA