

TECH NOTE

The Sustainable Refrigeration Technology Behind The BioArc Ultra



MIRAI



AZENTA
LIFE SCIENCES

Advanced Air-Cycle Technology Cools the BioArc Ultra

Managing -80°C samples presents significant challenges, from maintaining precise temperature control to ensuring energy efficiency and reliability. The BioArc™ Ultra High Density -80°C Automated Sample Storage System supports your most challenging throughput needs with advanced, eco-friendly air-cycle refrigeration technology and a highly efficient storage design.

The Ultra is designed to eliminate ice buildup, minimize energy consumption, and provide precise, reliable cooling for -80°C environments. In addition, this sustainable refrigeration system reduces energy and carbon emissions up to 75%* compared to the equivalent number of manual freezers and has zero Global Warming Potential (GWP) and zero Ozone Depletion Potential (ODP).

The BioArc Ultra incorporates refrigeration units that use natural air as the refrigerant (R729). The refrigeration units are oil free, are more energy efficient, and produce less noise and vibrations compared to other alternatives.



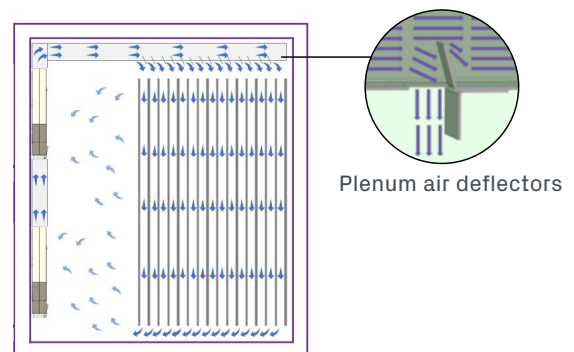
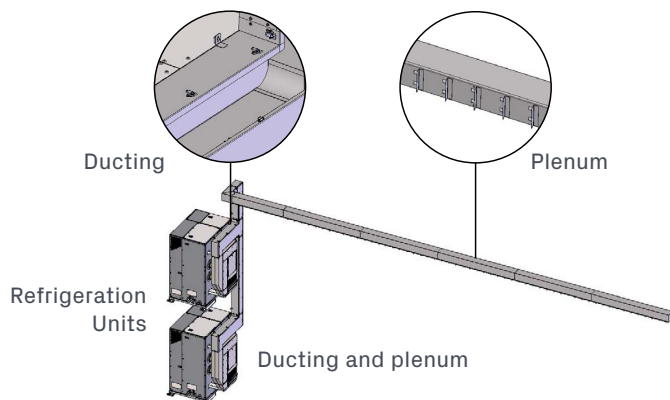
The BioArc Ultra Refrigeration System

The BioArc Ultra’s refrigeration system employs an open cycle process in which air is heated during compression, cooled through heat exchangers, and expanded in a repeated cycle to achieve ultra-low temperatures down to -160°C . By using natural air (R729) as a refrigerant, the system is eco-friendly and never needs coolant replenishing.

The temperature is regulated by a control set-point probe within the refrigeration unit that maintains $\pm 1^{\circ}\text{C}$ to ensure uniform cooling throughout the storage zone. Consequently, the sample storage area remains within

$\pm 3^{\circ}\text{C}$ of the set point, providing a stable and consistent environment for stored samples. Its open cycle system uses a plenum with air deflectors to deliver air directly into the chamber, ensuring uniform distribution and consistent downward airflow over samples.

Samples are stored on shelves in columns with high-density trays behind an insulated tile wall. To access samples, one tile at a time is lifted, exposing less than 1% of the storage area, which minimizes temperature fluctuations and protects sample integrity.



Airflow through the sample storage system

What Sets Air Cycle Technology Apart

The BioArc Ultra uses air cycle refrigeration technology from our partner MIRAI Intex. Air cycle refrigeration differs fundamentally from conventional vapor compression systems. By operating at low pressures, the expander and compression system minimize mechanical wear and enhance system safety. Since the expander outlet uses air bearings, there are no contracting parts, no oil, and no wear, which reduces maintenance. Additionally, the absence of internal evaporators or fans ensures uniform cooling without introducing localized heat sources, enhancing sample integrity.

The integration of turbo expander and compressor on the same shaft means energy produced during air expansion is transferred directly to the compressor, which reduces energy consumption by 30% compared to vapor compression.

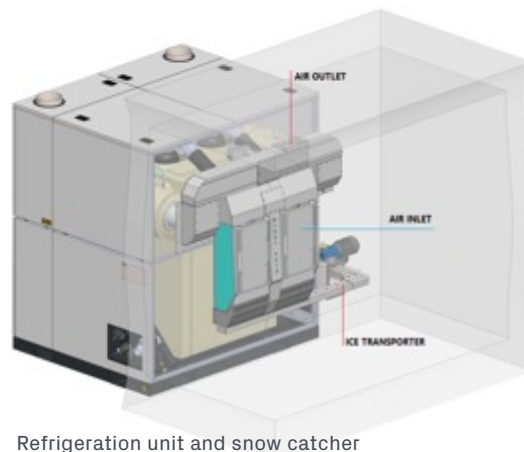
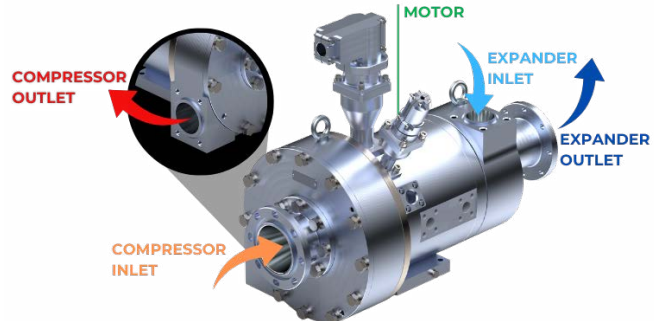
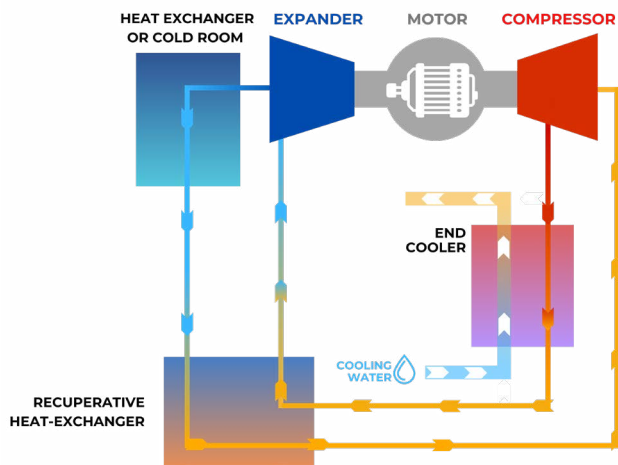
This approach results in a system that is not only energy-efficient but also inherently low-maintenance, making it a robust solution for high-demand environments. The refrigeration system combined with the BioArc Ultra design and high surface area-to-volume ratio result in power savings of up to 75% compared to equivalent manual freezers.

ELIMINATING ICE WITH ADVANCED DEHUMIDIFICATION

At ultra-low temperatures, moisture freezes instantly, leading to ice buildup in conventional systems. In common refrigeration technology, about 70% of the energy for defrosting goes into the cold room, causing the system to work harder to cool back down.

The BioArc Ultra combats this with a sophisticated Humidity Extraction Device (HED) that doesn't have an evaporator. The snow catcher removes moisture from the store by catching ice crystals in the filter. It then melts them and drains into the external wastewater drain. Instead, a snow catcher keeps the temperature stable, operating automatically at a low dew point, without ventilators or heaters creating additional heat. As a result, the Ultra can work continuously without the need for defrosting procedures that consume cooling power and additional energy.

MIRAI AIR-CYCLE REFRIGERATION



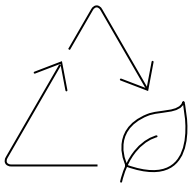
Refrigeration unit and snow catcher

PROVEN RELIABILITY AND SUSTAINABILITY

This technology has been used by Boeing onboard its 737 aircraft since 1967. In 2005, Mitsubishi Heavy Industries developed the first air as a refrigerant turbo compressor, and in 2015, our refrigeration partner MIRAI Intex started developing the technology for ULT trucks for cold-chain logistics and storage rooms with the first installation in 2018. They now have over 3.5 million operational hours across 200 installations worldwide without a single compressor replacement. Applications include ultra-low-temperature containers, pharmaceutical storage and sample preparation (such as lyophilization), and cold-chain logistics.

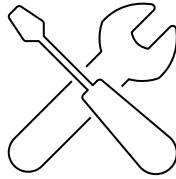
Azenta incorporated the MIRAI refrigeration system into the BioArc Ultra to achieve energy savings and sustainability goals. By reducing energy usage, maintenance requirements, and environmental impact, the Ultra provides a reliable solution for storing high-value samples in automated systems.

Key Advantages Of Air Cycle Refrigeration



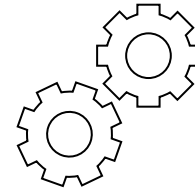
Environmental Sustainability

- Meets new environmental regulations
- No refrigerant leak detection needed
- 0 Global Warming Potential (GWP) and 0 Ozone Depletion Potential (ODP)



Low Maintenance

- No need for defrosting
- No oil management systems
- No need to replenish refrigerants (air is free)



Energy Efficiency

- No need for fans inside cold room
- Low dewpoint, resulting in less ice
- Up to 75% reduction in energy consumption*

*Compared to the equivalent number of 740-liter manual freezers with mid-range power efficiency, when storing 6,000,000 0.9 ml tubes + 25,000 SBS plates + 30,000 cryoboxes.