# Cryogenic Magnet Cooling Solutions

Stirling Cryogenics solutions for Magnet Cool-down

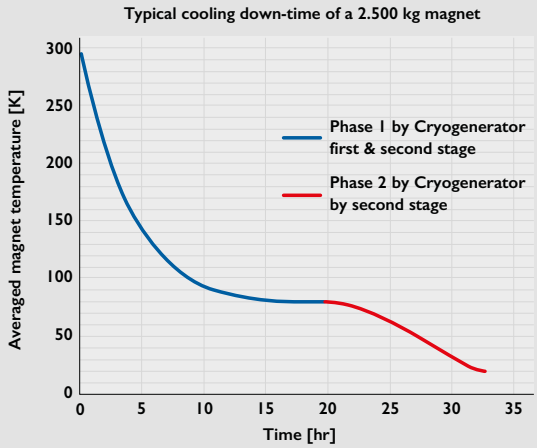
STIRLING CRYOGENICS

## Efficient & Fast Cool-down of Warm Magnets


Warm magnets, whether fresh from production or warmed up for maintenance, require efficient cool down. Traditionally, the first cooling stage uses liquid nitrogen ($LN_2$), which then needs to be removed by vacuum pumping. For the second stage, below 80 Kelvin (K), an internal cryocooler, cold helium gas, or liquid helium (LHe) is used. While using 4 K cold helium can be fast, it's quite inefficient due to the significant temperature difference until low temperatures are reached. Relying solely on the internal cryocooler, however, would prolong the cool-down time considerably.

To address these challenges, Stirling Cryogenics has developed an automated cool-down system, circulating cold helium through the magnet in a closed loop. The process begins by connecting the system to the magnet, then vacuumizing and purging the magnet and connecting lines. After that, this loop is pressurized, and the Cryogenerator and CryoFans are activated.

Both stages of the Cryogenerator are used to provide cooling power down to 60 K, as this range requires the removal of most of the magnet's thermal energy. From 60 K downwards, the first stage is bypassed, and cooling continues solely with the second stage, further reducing the temperature to 20 K.




Once the target temperature is reached, the helium in the loop is buffered, and the internal magnet volume is detached and sealed to prevent air entry. The Stirling system is then ready to cool-down the next magnet or set of magnets.

This concept of using a Stirling Cryogenerator results in a much more efficient and faster cool-down. For example, a 2,500 kg magnet that previously took 5 days to reach 20 K can now achieve this in just 1.5 days. At this point, the magnet's internal cryocooler takes over to reach 4 K. Since the Stirling system has removed most of the thermal heat, this final cool-down phase is significantly shorter than if starting from ambient temperature.

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## Stirling Technology

For over seventy years, Stirling Cryogenics has been designing and manufacturing systems for on-site production of cryogenic cooling power and various closed-loop cryogenic cooling concepts. We've served customers worldwide across diverse applications requiring cryogenic cooling under all possible conditions.

To cool these applications, Stirling Cryogenics offers several solutions based on our two product lines:

- Stirling Cryogenerators: These are designed for on-site production of cooling power, suitable for liquefaction and cooling from ambient temperatures down to 18 K.
- Cryogenic Fluid Pumps and CryoFans: These create closed cooling loops for $LN_2$ and gaseous helium.

Based on these components, we provide various system concepts tailored to specific application requirements. For magnet cool-down, our solutions include the SPC-4T 2-stage Cryogenerator to reach 20 K and a CryoFan to facilitate heat transfer from the magnet to the Cryogenerator via helium flow.

## Helium gas cooling loops using CryoFans

When cooling magnets or other devices down to 20 K, pressurized helium gas is the preferred medium. Our CryoFans circulate this gas, creating a thermal connection between the application and the cold source. This concept allows cooling power to be distributed throughout the mass being cooled, minimizing temperature gradients. Our CryoFans are designed for minimal heat loss due to static heat in-leak and high pump efficiency, maximizing available net cooling power.

## Generation of cooling power by Stirling Cryogenerators

Our Cryogenerators use the Stirling Cycle to generate cooling power. In short, by compression and expansion of helium gas in a closed cycle using mechanical pistons, cold is created which is used to cool a heat exchanger. The medium to be cooled is not used to create this cold: it will just flow through a cold heat exchanger where energy is extracted cooling the process.

Typical cooling capacities for different Stirling Cryogenerator types include:

- 250 W @ 20 K
- 4 kW @ 77 K
- 12 kW @ 200 K


## Magnet Applications

Our systems are typically used in magnet applications for:

- Efficient and fast cool-down of magnets:
  - From 300 K to 80 K in Phase 1
  - From 80 K to < 20 K in Phase 2
- 20 K & 80 K cooling of shrouds and current leads

**Stirling Cryogenics BV**
Science Park Eindhoven 5003
5692 EB Son, The Netherlands
T +31 40 26 77 300
info@stirlingcryogenics.com

Sales Offices in USA, Germany, Sweden and Italy