



**STIRLING  
CRYOGENICS**

# Closed Loop Cryogenic Cooling Systems

For Aviation and Space Tech Applications

## Stirling Technology

For over seventy years Stirling Cryogenics has been designing and manufacturing Cryogenerators for extreme low temperature cooling, serving customers all over the world under all possible conditions. This experience is incorporated in our various cooling concepts, which have typically the following applications in Space Tech:

- Cooling of vacuum chamber shields and test objects down to 20 K by GHe or down to 68 K by LN<sub>2</sub>.
- Densification of liquid cryogenics by sub-cooling.
- Hydrogen (re-)liquefaction.
- Cooling of superconductive devices

To generate cooling power the Stirling Cycle is used. 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. For instance, a flow of helium gas, sub-cooled LN<sub>2</sub> or LH<sub>2</sub> and LOX.

## Cooling of Shields and Test Objects

Satellites or their parts will need to be tested in environments simulating space conditions. Space chambers are equipped with shields and mounting tables that need to be cooled to obtain these conditions. Stirling Cryogenics can design and build cryogenic systems to supply a cooling flow to mimic these circumstances, cooling both shields and mounting tables.



Two-stage Stirling Cryogenerator type SPC-1T;  
cooling shielding of a vacuum chamber at both 80 and 20 K temperature level (1960's)

For testing in the range between 95 down to 67 K, we can provide a flow of LN<sub>2</sub>, which is fed back to the Stirling system to either be re-liquefied or re-cooled in case of a mono phase system.

If lower temperatures are required, e.g. for vacuum pumping, GHe is used in a loop at 15 to 20 barg. This is circulated by one of our CryoFans, creating a thermal connection between the application and the Cryogenerator.

Available cooling power ranges from 500 W to over 10 kW at 68 K or higher, and 50 W to 1 kW at 20 K.

### Generation of cooling power by Stirling Cryogenerators

Typical cooling capacities for different Stirling Cryogenerator types:

- 50-250 W @ 20 K
- 1-4 kW @ 77 K
- 12+ kW @ 200 K

### Densification of liquid cryogenics by sub-cooling

By increasing the density of cryogenic liquids like LH<sub>2</sub> and LOX, more mass can be stored in the same volume, which is beneficial aboard of launch vehicles.

Stirling can provide this densification by pumping the liquid cryogen in a loop from the vessel through the Stirling heat-exchanger, taking out heat and thus lowering the temperature. This process can be continued until nearly reaching the freezing point, providing maximum density.

### Production and re-liquefaction of LH<sub>2</sub>

With the ability of our two-stage Cryogenerators to reach 20 K, Stirling has built hydrogen liquefaction as well as re-liquefaction systems since the 1960's. Systems producing liquid hydrogen from feed gas can range from 5 to 2.000 kg/day of LH<sub>2</sub> production, including of transfer tanks and containerisation. LH<sub>2</sub> vessels can be made to be zero-boil off by reliquefying the cold H<sub>2</sub> gas and feeding this back, or by cooling an internal heat-exchanger condensing the gas within the vessel volume.

### Cooling of superconductive devices in Aviation

With the goal to decarbonise flight, the aviation industry has started programmes to develop superconducting electric motors, cables and power electronics. These will need cryogenic cooling, usually by a GHe flow, for which Stirling has built various systems with different concepts over the last two decades.



### Helium gas cooling loops using CryoFans

To cool shields or devices for aviation down to 20 K, the medium of choice is pressurized helium gas. This is circulated by our CryoFans, thermally connecting the application to the cold source. With this concept, cooling power can be distributed throughout the surface or mass to be cooled, minimizing temperature gradient. Our CryoFans are designed for minimal heat losses due to static heat in-leak and pump efficiency, maximizing available net cooling power.



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