

TECHNICAL SPECIFICATION

StirLIN-4 Extendible Liquid Nitrogen System



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1. INTRODUCTION

The Stirling Cycle based systems of DH Industries are based on technology which has been used for over more than sixty years, serving customers all over the world under all possible conditions.

This experience has culminated in our current range of systems called StirLIN, producing liquid nitrogen in volumes from 60 to more than 3.000 liters per day.

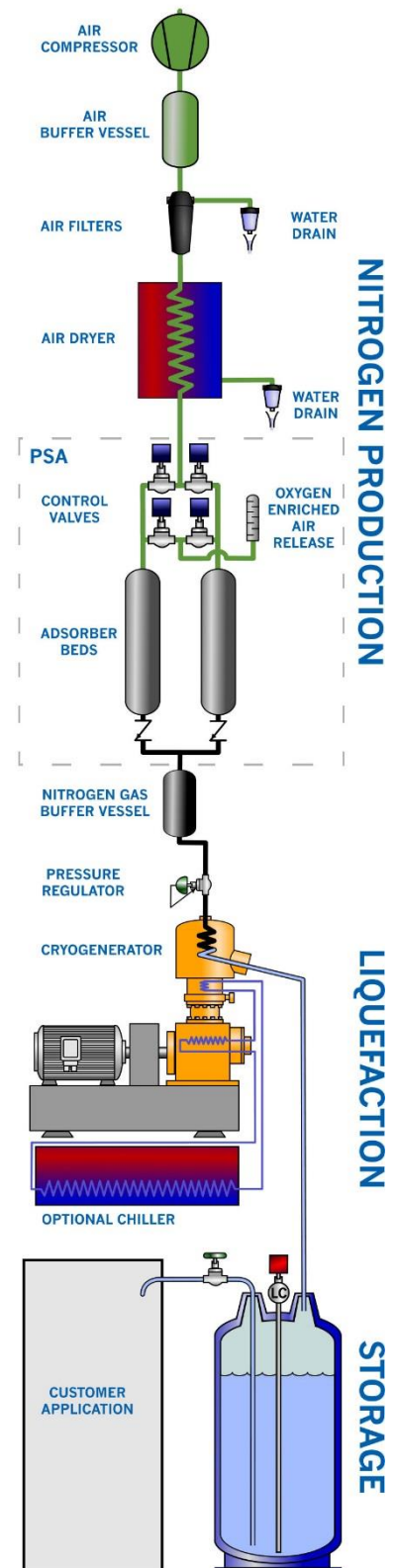
Our fully automatic StirLIN allows the user to concentrate on his core activity, eliminating all issues involved with the purchasing and logistics of bulk liquid nitrogen supply.

This document contains detailed technical information and specifications for the StirLIN-4 Extendible system.. We trust that this information demonstrates that our system will be a valuable asset in meeting your liquid nitrogen demand.

Thank you for your interest in our company and our products and we look forward to receiving your valuable response.

2. SYSTEM PROCESS DESCRIPTION

1. Ambient air is taken in by a compressor and fed to a buffer vessel.
2. The air then passes a number of filters for cleaning and to remove moisture and particles.
3. An air dryer removes the remaining moisture.
4. The dry, clean air is directed via PLC controlled valves to one of the two-absorber beds of the Pressure Swing Adsorption (PSA) unit.
The principle of PSA is based on the property of carbon molecular sieve to adsorb oxygen molecules until saturation. The time for adsorption in an adsorber bed is approximately one minute. After this time, the automatic valves will switch over to the second adsorber bed. The PSA bed just taken off-line is now regenerated by releasing oxygen enriched air (with 25-30% oxygen) to atmosphere. Continuous switching from one bed to the other generates a constant flow of purified nitrogen gas.
5. The nitrogen gas flows, via a buffer vessel, to an adjustable pressure regulator. This is set to the pressure at which the customer requires the liquid nitrogen to be stored in the vessel.
6. The Stirling Cryogenics Cryogenerator will extract heat from the nitrogen gas flow, due to which it is first cooled and then liquefied at cryogenic temperature. This cooling power is generated by the Cryogenerator using the Stirling cycle. The produced liquid nitrogen flows by gravity through an insulated line into the storage vessel.
7. Water cooling required for the cryogenerator can either be tap water, or by a dedicated water chiller available from Stirling Cryogenics.
8. The PLC will stop the StirLIN when the vessel is full, and automatically re-starts when the level drops to 80% due to liquid withdrawal.
9. Liquid nitrogen can be withdrawn from the vessel via a flexible delivery line by opening a manually operated valve. In this way small dewars can be filled.
For applications with an auto-fill system, a direct connection line can be made between the Stirling Cryogenics vessel and the application.
10. Liquid nitrogen withdrawal is independent from the system's operation mode. There is no requirement for a mechanical transfer pump.



3. TYPICAL StirLIN FEATURES

This chapter introduces the functionality and specifications of the StirLIN range and the advantages that on-site liquid nitrogen production will provide to your organization.

- Ease of installation.
With the system room and utilities prepared prior to the arrival of the system, the StirLIN will be producing liquid nitrogen within a few days after opening of the crate.
During the visit of one of our service engineers the StirLIN will be installed and commissioned. Your personnel will be trained how to optimally operate the system.

- Fully automatic operation by PLC control.
All StirLIN systems are monitored, controlled and safeguarded by a Programmable Logical Controller (PLC). Through the display, the operator is continuously informed about the operational status of the system such as the liquid nitrogen level in the storage vessel. For efficient troubleshooting, messages of the safety devices are indicated as error codes that refer to the operator manual for further action.

The PLC will automatically stop and start the StirLIN depending the level of liquid in the storage vessel. In case of power or water supply failure, the PLC automatically re-starts the StirLIN when the supply is restored.

- Extendible LN₂ production capacity .
Our Extendible StirLIN's are the solution for customers of which the LN₂ consumption is expected to grow in the future. By offering the StirLIN Extendible systems, customers do not need to invest in a system that is too large for this moment, while giving them the opportunity to easily double the capacity in the future, without the need to purchase a second system.

The Extendible systems are prepared for future growth in LN₂ consumption. All components are sized for increased capacity with all the necessary connections and controls already integrated.

The main system is delivered with only one SPC cryogenerator, which determines its initial capacity. Once LN₂ consumption of the customer has grown to such extend that increase production capacity is required, the customer can purchase the second cryogenerator and water chiller. By connecting this to the already prepared existing system, the LN₂ production rate of the system is doubled.

- Adjustable liquid nitrogen pressure.
The StirLIN is equipped with a pressure regulator to adjust the pressure at which the liquid nitrogen is kept in the storage vessel. This allows the customer to choose the pressure that best suits his application. This also prevents high losses by flashing due to unnecessary over pressure in the storage vessel.
- Efficient production.
The StirLIN's are designed around the highly efficient Stirling cycle. Economical use of electrical energy results in low electricity consumption per liter of LN₂ produced.

- Easy liquid nitrogen dispense.
The storage vessel is equipped with a manual valve and a flexible delivery hose. Dispensing of liquid nitrogen can be done in several ways, depending the type of dewar to be filled:
 - Open dewars are filled by placing them beside the StirLIN vessel and dispensing the liquid through the flexible hose into the dewar opening.
 - Closed dewars can be filled by connecting the flexible hose to their fill connection and opening valves according instructions of dewar manufacturer.
 - For applications with an auto-fill system, an optional direct connection hose can be installed between the StirLIN vessel and the application.
- Low noise level.
The noise level of the StirLIN is only 70 – 74 dBA depending on the type of StirLIN. This allows a normal conversation in the system room in direct vicinity of the system.
- Built for stringent climate conditions (and adaptable to extremes).
Functional specifications of StirLIN systems are defined at the nominal conditions of 250 m altitude and 25°C air temperature. Their working range is however much larger. At altitudes up to 2.000 m or temperatures up to 45°C ambient temperature a standard StirLIN will still perform. For more extreme circumstances a StirLIN can be adapted to your specific climatic conditions such as high altitude or hot deserts.
- The StirLIN range is available for all common, worldwide used, 3-phase power supplies, i.e. 110V to 500V and 50 Hz or 60 Hz.

4. StirLIN CUSTOMER SERVICE

Worldwide service support

StirLIN systems are made for the future, not just to meet the sheer functional specifications; they are designed to ensure minimal service effort. This is supported by our Customer Service philosophy and organization.

- **Low operator attention**
The operators' activities are limited to a daily routine check, regular cleaning/replacement of filters and simple compressor oil changes.
- **Low maintenance**
Maintenance on the StirLIN shall be done only every 6.000 hours of operation and will take approximately one day.
- **On-site maintenance**
Maintenance on all components of the StirLIN systems including the Stirling Cryogenics cryogenerator can be done on-site. There is no requirement of shipping components back to the factory for maintenance or repair, meaning less down-time and transport costs.
- **10 Years supply of spare parts**
DHI guarantees the supply of spare parts for any given StirLIN component for a period of 10 years after shipment of a system.
- **World-wide Service Network**
DHI Service Engineers or its Certified Service Representatives are available from Stirling Cryogenics to assure service support anywhere in the world.

Maintenance

Each StirLIN system requires preventive (minor) maintenance only after each 6,000 operating hours. Specific Consumable parts sets are available for this maintenance (please see our price quotation). At 36,000 operating hours each StirLIN system requires a more extensive (major) maintenance. All maintenance inspections can be done at site by our Service engineers.

As an option, also customer technicians can be trained to perform this maintenance but they need to be officially certified. A (regular) training at our premises is mandatory in this case.

Maintenance inspection	Interval [operating hours]	Duration (on site)
Preventive (minor) maintenance	every 6,000 hours	8 hours
Extensive (major) maintenance	36,000 hours	16 hours

Note: the StirLIN system has to be shut down (to be warmed up) at least 24 hours before commencing with each maintenance.

Service Level Agreements

Since DH industries cryogenic systems are the most reliable on the market they are often provided with new product related parts for new product applications. When our machines are maintained properly, many years of high performance and uninterrupted productivity are ensured at an extremely cost-effective level.

In case you cannot find what you need in our service program, we are more than happy to develop a tailor made service program specifically for your facility.

- **Parts warranty**
Every new machine includes standard 12 months warranty on parts as mentioned in the Orgalime Conditions which are applicable for DH Industries Cryogenic systems
- **Parts purchase**
In order to maximize your production output, parts can be purchased to ensure availability for planned maintenance as well as unexpected maintenance. Depending on your requirements and budget, parts can be offered.
- **Maintenance**
DH Industries can handle structural maintenance of your machine. While maintenance is performed by our experts, and optimum condition of the machine can be ensured, resulting in maximum up-times.
- **Response times /24/7**
To ensure minimum downtime in case of emergencies, we can offer shortened response times. This minimizes the time for an engineer to arrive on site in case of emergencies in order to ensure a swift restart of production. This in combination with a ensured 24/7 helpdesk service to support you at our best.
- **Remote service**
DH Industries can provide maximum technical support while not being on site via remote service. By logging into the machine remotely, Our engineers can monitor the machine status, make changes when required and advise operators and maintenance personnel.
- **Training**
DH Industries can provide training in the format that best meets the needs of your facility and staff helping your employees to become valuable experts. Typically the training consists of a balanced combination of classroom-style training and hands-on training at the machinery, optimizing skill development. The training included handouts and teaching aids as needed.
- **Overhaul**
DH Industries can handle yearly overhauls of your machinery. While the overhaul is performed by our experts, an optimum condition of the machine can be ensured, resulting in maximum up-times.

5. StirLIN-4 Extendible SCOPE OF SUPPLY

The Scope of Supply of the StirLIN-4 Extendible consists not only of the actual system but also includes all additional materials to ensure a proper installation and functioning of the plant.

Main system:

- Nitrogen gas production module including:
 - One air compressor
 - One air buffer vessel
 - One air dryer
 - One set of air filters
 - One Pressure Swing Adsorption module (PSA)
 - One nitrogen buffer vessel
 - One control box with monitor display using PLC technology

- Liquid nitrogen production module including:
 - One 4-cylinder Stirling Cryogenics cryogenerator
 - One 2.000 liters storage vessel, equipped with three necks; one connected to the cryogenerator with an insulated pipeline, the second containing a level sensor to measure the liquid level and a flexible hose with a manual valve to dispense liquid. The third is blanked off for the future extension by a second 4-cylinder Stirling Cryogenics cryogenerator.

Additional materials:

- Set of Installation materials
- Helium gas cylinder
- Pressure regulator for helium gas cylinder
- Oil for cryogenerator and compressor

Documentation (in English):

- Pre-installation manual including lay-out details
- Operating and maintenance instructions
- CE declaration of conformity

The StirLIN-4 Extendible will be tested at the factory for its performance according out standard test procedure. Customer can witness the final 2 days of Factory Acceptance Test at its own cost. Additional factory acceptance test/requirements need to be discussed and might be subject to additional charges.

Options:

2) Water Chiller:

Each Stirling Cryogenics Cryogenerator needs cooling water to dissipate the heat generated by the Stirling Cycle. The cooling water can either be supplied by a cooling water circuit or tap water (made available by the customer) or by a dedicated water chiller. This dedicated water chiller can be supplied by DHI.

3) Voltage Stabilizer:

The main function of a stabilizer is to make the output voltage that feeds the StirLIN connected to it as much as possible equivalent to the ideal electrical power supply, ensuring that the oscillations in electrical power are offset, and its output maintain a stable value, preventing them from being experienced by StirLIN and thereby avoiding their damage.

4) Gas Tap:

If the LN₂ production capacity of the StirLIN system is not fully needed, a gas tap set can be added which allows Nitrogen gas at room temperature to be tapped from the StirLIN system while the StirLIN system is not producing LN₂.

5) Automatic LN₂ transfer:

An automatic LN₂ transfer set can be added which allows the StirLIN system to run even if the production capacity exceeds the storage capacity of the StirLIN system. By adding this set, a second tap line is installed with a solenoid valve instead of a hand valve. A second vessel can then be connected to this second tap line and once enough LN₂ is present in the LN₂ vessel of the StirLIN system, the solenoid valve will open and transfer LN₂ to the second storage vessel.

6) Water temperature set:

A water temperature set can be added which allows the StirLIN system to check the cooling water temperatures and stop the StirLIN system if the temperature becomes too high. Together with the absorbed electrical power and the cooling water flow.

By adding this set, a temperature sensor is added in the inlet water hose and outlet water hose of the StirLIN system.

7) Generator set:

When power failure is likely to happen or it cannot be afforded to have the StirLIN system shut down due to power loss, this generator set will provide the power needed to ensure LN₂ production.

8) Remote monitoring:

All StirLIN PLC Control Cabinets (Siemens based) include local control of the system through a Touch Screen. Besides this local accessibility, DHI also offers 3 different options for remote monitoring and on/off control.

8a) 2nd Touch Screen, either wired or remote by WIFI (intranet or internet)

An extra Touch Screen which can be positioned in e.g. the customers' control room. From this Touch Screen, the customer can remotely read out all system information and can manually stop and start the StirLIN as required.

The 2nd Touch Screen shall be connected over the customers' intranet. The maximum of extra displays is 2. The display can also be taken over by a pc on the local network

8b) Integration in the customers' control system through OPC Server

In this option, the customer is able to read out all relevant I/O signals of the StirLIN through an OPC server. The customer can incorporate these data in his own control system, e.g. to monitor operation and store data.

From the customer system control, the StirLIN can be stopped and started as required. Several communication protocols (Profibus, Modbus, Ethernet/IP, etc.) are available upon request

8c) On a mobile device or PC over Internet

A modem will be added to the StirLIN Control, which the customer shall connect to the Internet through a local router. Through a password the customer can now have access using any computer, smartphone or mobile, with a maximum of 2 logins (VPN connection) . On this device the customer can monitor the StirLIN and start and stop it as required. To notify the operator in case of an alarm, the internal modem will send an SMS message to up to 5 phone numbers.

This option also allows the Stirling Cryogenics Service Centre to access the StirLIN for support and to read the stored data. In case of a Service contract, this option is mandatory to allow maximum system uptime.

9) LN₂ dispensing register:

In case the LN₂ produced by the StirLIN is used by different departments, it can be useful to register who uses how much liquid. All certified users will receive a code with which they can identify themselves before tapping liquid. The station will register the duration of time the LN₂ tap is kept open. This is a measure for the amount of liquid that is withdrawn. The station keeps a record that shows who has tapped for how long, and when. This data is made available in a data file to the administration. This data gives insight in the relative consumption of the different users and allows to charge for these quantities. Also, due to the registration people will be more aware of the costs of liquid nitrogen and handle it with more consciousness, avoiding spillage or unnecessary cool-down of vessels.

6. TECHNICAL SPECIFICATION StirLIN-4 Extendible

The StirLIN-4 Extendible liquid nitrogen plant has the following specifications.

Liquid nitrogen production capacity at nominal conditions¹

LN ₂ produced at	[barg]	1	3	5
Purity (nitrogen + inerts)	[%]	99,7 (99)	99,5 (98)	99,5 (98)
Production capacity	[l/h]	48 (97)	64 (124)	75 (151)
Expanded to atmospheric pressure (usable liters) ²	[l/h]	44 (89)	49 (98)	53 (106)

* (...) l/s after extension to StirLIN-8

¹ Working range; system room temperature 5-45°C, altitude 0-1.450 m, relative humidity 20-95%.

² When high-pressure liquid nitrogen is transferred and expanded to a lower pressure, up to 30 percent of the liquid quantity can be lost through evaporation flashing. That is why Stirling Cryogenics presents its production also as the amount of liquid nitrogen available when used at normal atmospheric pressure, besides the amount produced in a liquid vessel at higher pressure. This is what we call usable liters of liquid nitrogen.

Additional specifications

		StirLIN-4 Extendible	Optional water chiller
System size	l x w x h; m	4,90 x 4,34 x 2,00	2,70 x 1,10 x 1,60 (each)
Advised plant room	l x w x h; m	6,50 x 5,80 x 3,00	3,70 (7,30) x 2,10 x 2,60
Weight	kg	4.150 (5.200)	1.350 (each)
Power supply	V / Hz	adapted for local power supply	
Power consumption	kW	77 (122)	20 (40)
Noise level ³	dBA	72 (74)	60 (63)
Liquid nitrogen storage capacity	Litres	2.000	N/A
Maintenance interval (apart from oil and filter changes)	Running hours	6.000	N/A

³ Measured at 1,5m from the ground and 1m distance from the system. Peaks during blow off of PSA can occur.

StirLIN systems meet the European CE and PED safety standards, as well as the IP54 and IEC 60204.

For other national standards that may be applicable in your country, please contact Stirling Cryogenics to discuss the consequences.

Lay-out

Refer to the attached drawing, which gives the main sizes of the plant components and the different elements required in the room. The room set-up is an example to give an idea of required size. When an existing plant room is chosen, a new specific drawing can be made.

Remarks:

- Sizes are in mm.
- Actual plant room lay-out will be determined with the customer during the order stage based on actual plant room availability.
- Plant room shall be equipped with oxygen monitoring system as per local legislation for safety of personnel.
- Ventilation is required for proper functioning of the plant and safety of personnel. Ducts are recommended for areas with ambient temperatures above 25°C.
- Ventilation and air ducts to be installed by customer. Actual placement depends on position of outside walls.
- Doors are not shown because their position depends on building lay-out. Doors must be placed near the dewar fill area. Minimum door size is 1.700 x 2.300 mm.
- Provided ambient outside temperature does not drop below -10°C, the water chiller can be placed outside under a simple roof for protection against direct sun and rain. Maximum distance is 8 m from the StirLIN.

7. Standard Lay-out

