TECHNICAL SPECIFICATION

StirLAIR-1 Economy
“Breathable Air”
Liquid Air System

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Stirling Cryogenics is a registered trade name of DH Industries BV
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1. INTRODUCTION

Since more than sixty years Stirling Cryogenics has designed and manufactured liquid gas production systems, serving customers all over the world under all possible climatic conditions. This experience has evolved in our current range of systems called StirLAIR, producing liquid air.

The fully automatic StirLAIR systems allows the user to concentrate on his core activity, eliminating all issues involved with the purchasing and logistics of bulk gas supply.

In this document contains detailed technical information and specifications for the StirLAIR-1 Economy system producing “breathable air”. We trust that this information demonstrates that our system will be a valuable asset in meeting your cryogenic demand.

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

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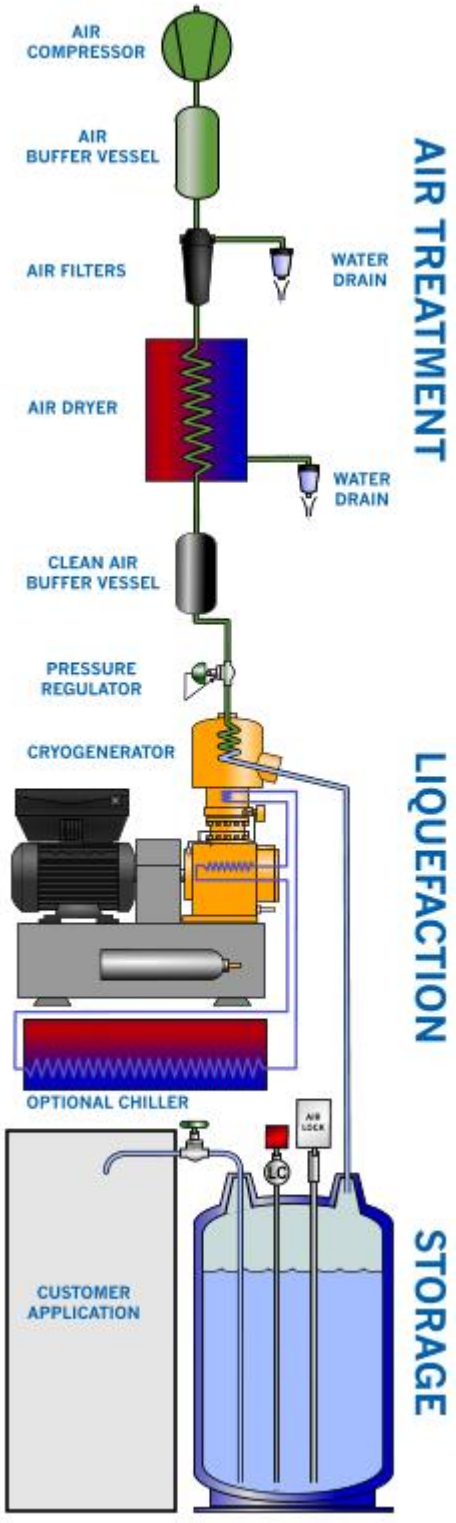
2. SYSTEM PROCESS DESCRIPTION

1. Ambient air is taken in by a compressor and fed to a buffer vessel.
2.
3. The air then passes a number of filters for cleaning and removes moisture and particles.
4. An air dryer removes the remaining moisture.
5. The clean air flows, via a buffer vessel, to an adjustable pressure regulator. This is set to the pressure at which the customer requires the liquid air to be stored in the vessel.
6. The clean air is liquefied by the cryogenerator after which the liquid air flows via an insulated pipeline by gravity into the storage vessel.
7. Water cooling required for the cryogenerator can either be ta water, or by a dedicated water chiller available from Stirling.
8. The optional AirLock system can prevent O_2 enrichment in the liquid air vessel.
9. The PLC will stop the StirLAIR when the vessel is full, and automatically re-starts when the level drops to 80% due to liquid withdrawal.
10. Liquid air can be withdrawn from the vessel via a flexible delivery line by opening a manually operated valve.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 vessel and the application.
11. Liquid air withdrawal is independent from the system's operation mode. There is no requirement for a mechanical transfer pump.



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3. TYPICAL StirLAIR FEATURES

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

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

- Fully automatic operation by PLC
  All StirLAIR 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 liquid air 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 StirLAIR depending the level of liquid in the vessel. In case of power or water supply failure, the PLC automatically re-starts the StirLAIR when the supply is restored.

- Easy liquid air dispense
  The storage vessel is equipped with a manual valve and a flexible delivery line. Dispensing of liquid air can be done in several ways, depending the type of dewar to be filled:
  - Open dewars are filled by placing them beside the StirLAIR vessel and dispensing the liquid through the flexible line into the dewar opening.
  - Closed dewars can be filled by connecting the flexible line to their fill connection and opening valves according instructions of their manufacturer.
  - For applications with an auto-fill system, an optional direct connection line can be made between the StirLAIR vessel and the application.

- Adjustable liquid air pressure
  The StirLAIR is equipped with a pressure regulator to adjust the pressure at which the liquid air 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 StirLAIR's are designed around the highly efficient Stirling cycle. Economical use of electrical energy results in low electricity consumption per liter of LAIR produced.

- Low noise level
  The noise level of the StirLAIR is only 70 – 74 dBA depending on the type of StirLAIR. This allows a normal conversation in the system room in direct vicinity of the system.

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- Built for stringent climatic conditions, adaptable to extremes
  Functional specifications of StirLAIR 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 StirLAIR will still perform. For more extreme circumstances a StirLAIR can be adapted to your specific climatic conditions such as high altitude or hot desserts.

- The StirLAIR range is available for all common, worldwide used, 3-phase power supplies, i.e. 110V to 500V and 50 Hz or 60 Hz.

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4 StirLAIR CUSTOMER SERVICE

Worldwide service support

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

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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.

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5. StirLAIR Operational Safety

The StirLAIR system can be equipped with a number of (additional) operating safety devices, in order to prevent hazardous situations with liquid Air.

Which one that will be needed depends on the operation of the system and the usage of the liquid Air. Beyond the below mentioned options, additional features are available. Please contact us to discuss.

The AirLock System, preventing O_2 enrichment in liquid air vessels:

The AirLock System name, idea and concept are the sole proprietary of DH Industries BV

If liquid Air is stored for a long time there is a change of Oxygen enrichment in the liquid, due to the different rates of evaporation of Oxygen and Nitrogen.
With an AirLock System integrated in the LAIR storage tank, oxygen enrichment of liquid Air inside the storage tank becomes impossible and consistency of the liquid in the tank remains what it was: liquid air.

Oxygen Analyzer

In order to guarantee that the LAir that is going to the customers application is within the safety limits (typically between 19 -23% Oxygen) the system can be equipped with a Oxygen analyzer. In case the liquid air going to the customer's application is out of specification, measures can be taken.

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6. StirLAIR-1 ECONOMY SCOPE OF SUPPLY

The Scope of Supply of the StirLAIR-1 Economy consists not only of the actual system but also includes all additional materials to ensure a proper installation and functioning of the system.

Main system:

- Clean air production including:
  - One air compressor
  - One air buffer vessel
  - One air dryer
  - CO_2 absorber
  - One set of air filters
  - One clean air buffer vessel
  - One control box with monitor display using PLC technology

- Liquid air production skid including:
  - One 1-cylinder Stirling cryogenerator
  - One 300 liters storage vessel, including a level sensor to measure the liquid level, flexible hose with a manual valve to dispense liquid.

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 StirLAIR-1 Economy 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.

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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 StirLAIR 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 StirLAIR and thereby avoiding their damage.

4) AirLock System:

This option can be integrated in the Lair Storage tank to prevent Oxygen enrichment of the liquid. Recommended in case the liquid in the tank is expected to be stored over long(er) periods of time.

5) Oxygen Analyzer:

Oxygen Analyzer on the outlet of the system, safeguarding the Oxygen content of the liquid going to customers application. This option includes an automatic shut off valve.

6) Automatic LAIR transfer:

An automatic LAIR transfer set can be added which allows the StirLAIR system to run even if the production capacity exceeds the storage capacity of the StirLAIR 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 LN_2 is present in the LN_2 vessel of the StirLAIR system, the solenoid valve will open and transfer LN_2 to the second storage vessel.

7) Generator set:

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

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8) Remote monitoring:

All StirLAIR 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 StirLAIR 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 StirLAIR 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 StirLAIR 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 StirLAIR 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 StirLAIR 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 StirLAIR for support and to read the stored data. In case of a Service contract, this option is mandatory to allow maximum system uptime.

9) LAIR dispensing register:

In case the LAIR produced by the StirLAIR 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 LAIR 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 un-necessary cool-down of vessels.

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7. TECHNICAL SPECIFICATION StirLAIR-1 Economy

The StirLAIR-1 Economy liquid air system has the following specifications.

Liquid air production capacity at nominal conditions[1]

LAIR produced at	[barg]	1	3
Production capacity	[l/h]	5,8	7
Expanded to atmospheric pressure (usable liters)[2]	[l/h]	**5**	**5,5**

Nominal operating conditions: System room temperature 25°C, altitude 250m, relative humidity 95%, cooling water temperature 15°C, power supply: voltage ± 5%, frequency ± 2%.
Working range; system room temperature 5-45°C, altitude 0-2.000 m, relative humidity 20-95%.
When the ambient conditions differ from nominal, the specifications might differ.

[2] When high-pressure liquid air 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 presents its production also as the amount of liquid air 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 air.

Additional specifications

		StirLAIR-1 Economy	Optional water chiller
System size	l x w x h; m	1,99 x 2,24 x 2,15	1,64 x 1,27 x 1,60
Advised system room	l x w x h; m	3,30 x 4,30 x 3,00	2,65 x 2,27 x 2,60
Weight	kg	1,425	450
Power supply	V / Hz	adapted for local power supply	
Power consumption	kW	10	6
Required Cooling water @ 15°C and 20% glycol	Ltr/hr	1,250	NA
Noise level	dBA	72	60
Liquid air storage capacity	Liters	300	NA
Maintenance interval (apart from oil and filter changes)	Running hours	6,000	NA

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Breathing Air specifications:

The liquid Air produced by the StirLAIR-1 Economy will have the following specifications:

Oxygen Content:	19-23 (vol) %[1]
Carbon Dioxide (CO_2):	< 50 ppm
Carbon Monoxide (CO):	< 10 ppm
Water (H_2O):	< 5 ppm
Total Hydro Carbons: (As Methane)	< 25 ppm

[1]: In case the produced liquid Air is stored for a long time, precautions need to be made to to prevent Oxygen enrichment of the liquid. Options are available. Please contact us to discuss.

[2]: (liquid) gas analysis is not included. Please contact us to discuss in case this is needed.

StirLAIR systems meet the European CE and PED safety standards, as well as the IP54 and IEC 60204. For applications in the USA the equipment will be UL listed, where applicable. For other national standards that may be applicable in your country, please contact Stirling to discuss the consequences.

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