LAUDA

CONSTANT TEMPERATURE SOLUTIONS FOR THE HYDROGEN INDUSTRY

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HYDROGEN
Overview

Hydrogen – A promising energy source for the future
Hydrogen plays a decisive role in overcoming the challenges of energy transition. Whether used to store energy or for future mobility, hydrogen is an environmentally friendly solution with enormous potential. However, it is important that green hydrogen is produced efficiently using climate-neutral methods. The benefits of hydrogen as an energy source of the future are significant: It has a high energy content of 33 kWh/kg, in contrast to diesel fuel, which has only 10 kWh/kg.

Compared to combustion engines, a 5 kg tank of hydrogen can reach ranges of around 650 km in conjunction with an efficient system of fuel cells and an electric drive. Hydrogen electrolysis is also an excellent way to store surplus electricity from renewable energies. LAUDA's innovative constant temperature solutions address challenges in handling hydrogen during refueling.

Cooling solutions for electrolyzers and compressors
LAUDA offers innovative cooling solutions that are used worldwide in electrolyzers and hydrogen purification for hydrogen production. LAUDA Ultracool process coolers play a decisive role in cooling electrolyzers and compressors to make hydrogen production more efficient. Connectivity makes it possible to seamlessly connect, monitor and maintain these devices, making LAUDA cooling solutions the key to reliable hydrogen production.

Cooling systems for hydrogen filling stations

LAUDA offers state-of-the-art cooling solutions for hydrogen filling stations that facilitate the smooth operation of the refueling infrastructure. Since 2015, LAUDA has been developing and optimizing modular cooling systems that can be adapted to different pressure and temperature requirements and are used at filling stations for both passenger vehicles and heavy-duty transport vehicles as well as in tube trailers and trains.
An outstanding feature is the efficient cooling of compressors for pressure generation using LAUDA Ultracool process circulation coolers, providing a comprehensive solution.

Testing of fuel cell and hydrogen components

LAUDA's extensive experience in automotive testing seamlessly transitions into the hydrogen sector, with constant temperature equipment utilized for climate and environmental tests, component and material testing, and fuel cell performance evaluation.

EFFICIENT COOLING DURING PRODUCTION AND COMPRESSION

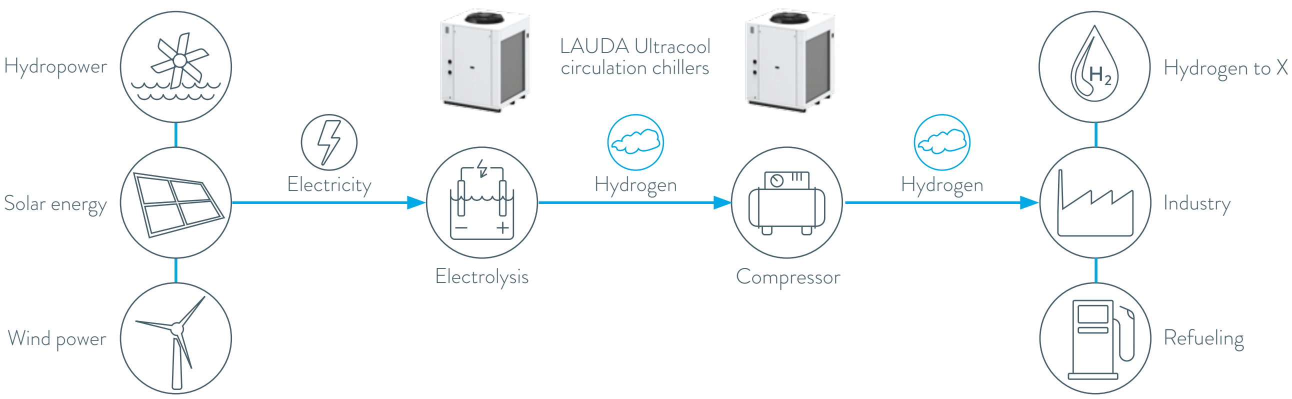
Drying and storage of hydrogen

−20 °C 35 °C

Cooling solutions for electrolyzers and compressors
LAUDA's cooling systems significantly enhance hydrogen production efficiency, globally utilized for years. They play a crucial role in electrolyzer cooling, as well as hydrogen drying and purification. Our customers rely on the new generation of LAUDA Ultracool devices.

Post-production, hydrogen undergoes compression, facilitated by LAUDA Ultracool devices. Their connectivity enables seamless interconnection, monitoring, maintenance, and data analysis, making LAUDA cooling solutions pivotal for reliable and efficient hydrogen production.

Cooling solutions along the entire value chain

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LAUDA ULTRACOOL

Energy-efficient process circulation chillers from −10 to 35 °C

Energy-efficient
Developed with a focus on energy efficiency, the LAUDA Ultracool circulation chillers make a pivotal contribution to reducing your operating costs. Compared to classic circulation chillers, the devices can reduce energy costs by up to 50 percent, depending on the operating conditions. This plays a very important role in increasing overall efficiency, especially in hydrogen production.

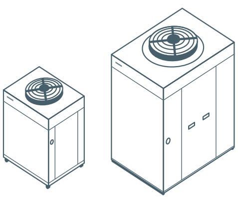
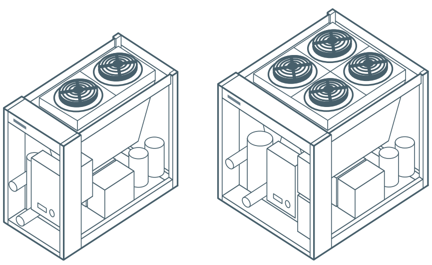
Optimized for Industry 4.0
Thanks to the innovative operating concept, the LAUDA Ultracool circulation chillers can be conveniently monitored and controlled from a distance – via a connected control panel or the integrated web server on a PC or laptop. A connection to LAUDA.LIVE allows device data to be saved, analyzed and used for remote maintenance.

Advanced technology for a broad range of applications
Extensive technical innovation and a significantly expanded range of functions characterize the various LAUDA Ultracool devices and additional equipment options. Custom options and a wide cooling output range make LAUDA Ultracool circulation chillers the ideal solution for a broad range of hydrogen-based applications.

Technical data

Device type	Working temperature range °C	Temperature stability ±K	Ambient temperature in °C	Cooling output at 20 °C Water outlet temperature[1] kW	Cooling output at 10 °C Water outlet temperature[1] kW	Nominal pump pressure in bar	Nominal flow rate in L/min	Pump connection thread	Water tank volume in L	Weight in kg	Protection level	SEPR*	Part Number
LAUDA Ultracool – specifications at 50 Hz													
UC 24	−10 … 35	0.5	−15 … 50	30.9	24.3	2.7	84.1	Rp 1	35	180	IP 54	5.63	L002855
UC 50	−10 … 35	0.5	−15 … 50	65.5	51.2	3.3	150.0	Rp 1 ½	210	410	IP 54	5.37	L002856
UC 65	−10 … 35	0.5	−15 … 50	85.2	66.9	3.3	196.0	Rp 1 ½	210	440	IP 54	5.16	L002857
UC 80	−10 … 35	0.5	−15 … 50	101.4	79.0	3.0	230.0	Rp 2 ½	125	700	IP 54	6.87	L003684
UC 100	−10 … 35	0.5	−15 … 50	121.4	95.3	3.0	287.0	Rp 2 ½	125	700	IP 54	6.2	L003685
UC 130	−10 … 35	1	−15 … 50		130.0	3.0	373.0	Rp 2 ½			IP 54	6.1	
UC 160	−10 … 35	1	−15 … 50		160.0	3.0	459.0	Rp 2 ½			IP 54	5.9	
UC 240	−10 … 35	1	−15 … 50		240.0	3.0	689.0	DIN-2566 DN 80			IP 54	5.9	

[1] at 25°C ambient temperature
*SEPR = Seasonal Energy Performance Ratio

	Device type	Cooling output range
	UC 24 UC 50 UC 65 UC 80 UC 100	24 … 95 kW
	UC 130 UC 160 UC 240	130 … 240 kW

FUEL CELLS AND COMPONENT TESTING

Temperature control on test benches and systems

−40 °C 140 °C

Decades of experience

For many years, LAUDA has been a leading provider of innovative constant temperature technology in test bench construction for the automotive, electrical and aviation industries, and can now apply this extensive experience to the development of components and systems for the hydrogen industry. The area of testing not only extends to hydrogen vehicles, but also to electrolyzers, filling stations, tanks and compressors.

Development of hydrogen technology

Components designed to interact with hydrogen undergo rigorous testing in specialized environments to guarantee optimal functionality and reliability during operation. One vital part of material testing is simulating extreme environmental conditions across different temperature ranges to increase the quality and safety of hydrogen technologies.

Testing in the development of hydrogen components

- Test benches for fuel cells and hydrogen combustion engines
- Accelerated service life testing for fuel cells
- End-of-line testing of components
- Load and performance tests of fuel cells
- Stability testing of materials
- Temperature stability and alternating tests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FUEL CELL TESTING

LAUDA Integral

Powerful constant temperature systems for test bench construction

Renowned quality

The Integral product line has proven itself in a wide variety of industries and applications for more than 20 years. Several thousand installations ensure the extensive testing and development of innovative components and systems on test benches in the automotive, electronics and aviation industries.

Testing hydrogen components

LAUDA Integral process thermostats are used in the automotive industry and by a large number of testing service providers to test fuel cells, components and hydrogen combustion engines, often in combination with LAUDA through-flow control units or LAUDA filling and emptying systems.

Powerful and dynamic

With a maximum cooling output of 35 kW, a maximum heating output of 24 kW, and a working temperature range of −90 to 320 °C, our integral process thermostats perform outstandingly well in every application.

Maximum connectivity

Fit for the future and ready for LAUDA.LIVE: Integral constant temperature systems can be flexibly integrated in various communication scenarios thanks to an integrated web server, monitoring and control via PC or mobile devices, and the modular interface concept.

User-friendly operation

Softkey control directly on the device, remote control via touch display or mobile devices mean that it has never been easier to control your constant temperature applications according to your requirements. The new Integral devices determine the optimum control parameters for the applica-tion at the touch of a button, and the temperature control media can be selected to ensure safe and optimum use of the liquid. The high-precision through-flow control unit extends your options and ensures you have control over your test and production processes.

LAUDA INTEGRAL XT

−90 °C – 320 °C

LAUDA Integral XT process thermostats with a cold oil blanket operate according to the flow principle and enable the utilization of temperature control media over a significantly larger temperature range – ideal for dynamic temperature control tasks.

The electronically controlled, magnetically coupled pump can set the flow rate optimally both for the requirements of pressure-sensitive consumers and for applications with high hydraulic resistance.

−40 °C **Water/glycol mixtures** 90 °C

−90 °C **Oils** 320 °C

LAUDA INTEGRAL P

−40 °C – 140 °C

The new **LAUDA Integral P** process thermostats function with a pressure blanket of up to 4 bar according to the through-flow principle. This allows non-flammable water/glycol mixtures to be used in a temperature range of −40 to 140 °C.

Thanks to the electronically controlled, magnetically coupled pump, optimized flow rates can be set for different applications.

−40 °C **Water/glycol mixtures** 140 °C

LAUDA FC 80 MID THROUGH-FLOW CONTROLLER

−40 °C – 140 °C

Compatible with Integral IN XT, IN P. through-flow control system with magnetic inductive measuring method. Control range 0.2 to 70 L/min, max. measuring range of 99 L/min.
Flow control accuracy (20 °C; 20 L/min; 1 bar): ±0.2 L/min

Process sequences and their changes can be simulated or heat quantities can be calculated during heating or cooling by controlling the volume flow. A high degree of measurement accuracy is essential for the consistent reproduction of test procedures.

−40 °C **Water/glycol mixtures** 140 °C

LAUDA FILLING AND EMPTYING UNIT FD 50

10 °C – 40 °C

Active filling and emptying system for thermostatic circuits with changing test specimens. A buffer volume of 50 L and manual or digital control of the filling and emptying stages displayed by pilot lamps guarantee maximum safety. Can be combined with FC 80 MID for reduced space requirements.

When the test specimen is changed during standardized test procedures, it is extremely advantageous if the constant temperature medium is first blown out with compressed air in a controlled manner and a leak test is performed using compressed air before the next test specimen is filled. In this way, the automation of tests can be expanded.

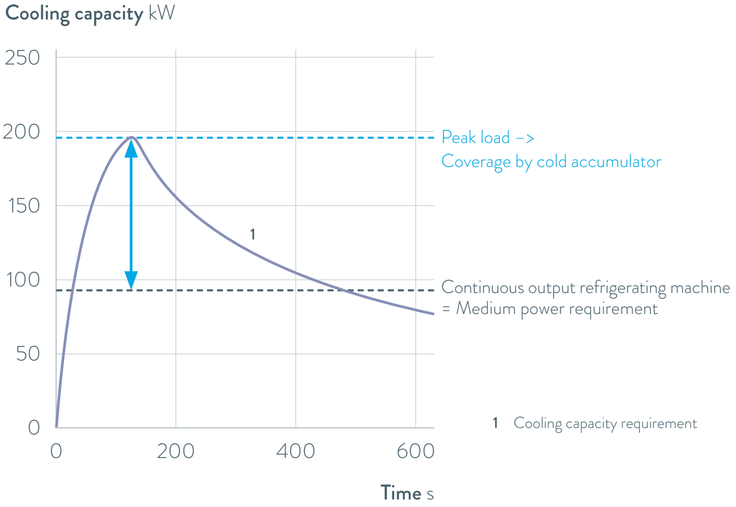
−40 °C **Water/glycol mixtures** 140 °C

COOLING SOLUTIONS FOR HYDROGEN FILLING STATIONS

Indirect cooling concept

The future of hydrogen mobility

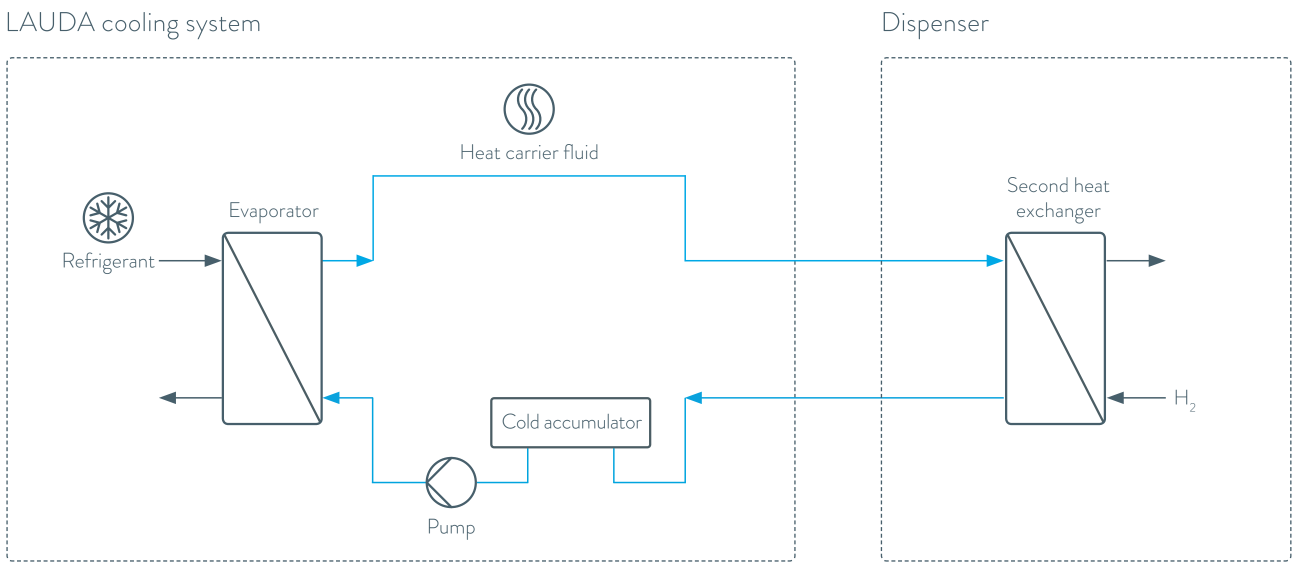
Our state-of-the-art cooling solutions for hydrogen filling stations make sure that the hydrogen infrastructure operates smoothly and efficiently. Since 2015, we have been developing and continuously optimizing our cooling systems through pioneering work. The modular systems are extremely flexible and can be adapted or extended to suit different pressure and temperature requirements. Our cooling solutions are utilized not only in conventional filling stations for both passenger and heavy-duty transport vehicles but also in tube trailers and for refueling trains. One key feature of our solutions is the efficient cooling of the compressors required to generate pressure by our LAUDA Ultracool process circulation coolers. We are therefore able to offer a holistic solution from a single source.



Cooling capacity requirement via refueling process

Benefits of indirect cooing

- Possible to design the system for average performance instead of peak performance using cold accumulators
- The system can be located away from the dispenser (e.g. outside the hazardous area)
- Modular concept for adapting or extending the system to suit different use cases
- Compact design



Indirect cooling system:
Evaporator cools using refrigerant. Heat carrier circuit cools hydrogen H_2.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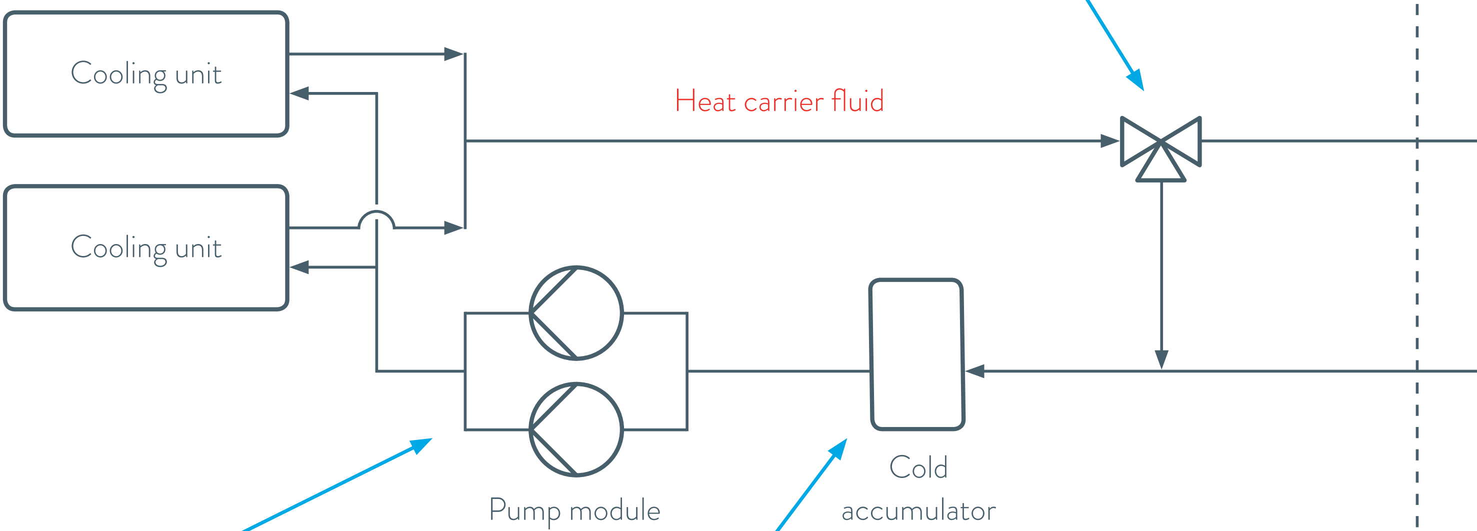
LAUDA PROCESS COOLING UNITS

Modular systems for different applications and future expansion stages

−50 °C 0 °C

Cooling unit is a direct evaporator that can have a redundant design to ensure maximum reliability and enable continued operation of the tank system, even during service campaigns. It also offers better partial load efficiency, which makes sense from an energy perspective, especially when demand is low. It is therefore possible to install just one cooling unit in a refilling station and add another module to the system as demand increases. The cooling unit has two refrigerant circuits in a cascade connection, which are operated with natural refrigerants.

Three-way valve, designed primarily to pre-cool the cold accumulator in standby mode. Even if there is a decrease in load at the fuel pump, the excess cooling capacity can be used to regenerate the cold accumulator during the refueling process in order to start subsequent refueling directly without a break.



Pump module, can be fitted with a powerful pump or with an additional redundant pump to increase reliability.
The pump capacity is designed specifically for the application.

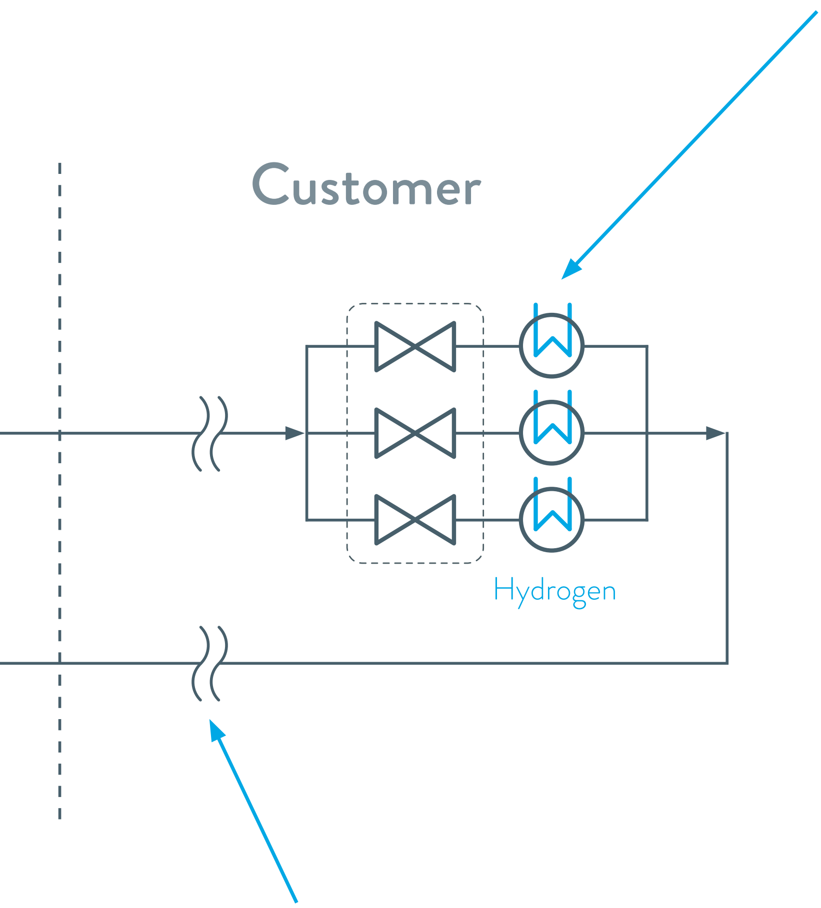
The volume of the **cold accumulator** containing heat carrier fluid can be adjusted according to the tank cycles and the accumulator can also be refilled via the three-way valve during the ongoing refueling process to achieve efficient back-to-back refueling.

LAUDA Process cooling unit SUK 350 L

Modular system – application spectrum*
- Refueling protocols according to SAE J2601
- Fuel delivery temperature category: T10 (−10 °C), T30 (−30 °C), T40 (−40 °C)
- Pressure classes: H35 (350 bar) – H70 (700 bar)
- Natural refrigerant
- Refrigerant circuit (chiller) in air/water-cooled design possible
- Pressure class up to 1000 bar
- Applications: Lightweight/heavy-duty vehicles, forklifts, trains, tube trailers, etc.
- Ambient temperature: −40 ... 50 °C
- Mean mass flow H_2: 150 g/s
- Peak mass flow H_2: 300 g/s
- Short refueling times/back-to-back refueling
- Distance to dispenser: usually up to 50 m
- ATEX possible
- Remote maintenance module

*based on current hydrogen projects, for illustrative purposes only.

A wide variety of protocols can be installed at the **fuel pumps**, for example, 1x350 bar and 2x700 bar for LDV and HDV. One possible solution, e.g. at high flow speeds and large volumes, can be implemented via the upstream valves so that power is channeled to the fuel pump where it is needed.



Cooling units can be located away from the fuel pumps. In terms of energy efficiency, distances of usually 50 m are possible. Explosion or noise protection can often be avoided as a result.

Customized solutions are developed individually by LAUDA System engineering. Due to the modular system, customized cooling systems can be developed for the respective application within a very short time frame, whether passenger vehicles, trucks, buses, etc. In order to develop a solution, the following information should be specified prior to concept creation:

- Fuel delivery temperature (e.g. T10,T20 or customer-specific)
- Pressure class (e.g. H35, H70 or customer-specific)
- Mean and peak cooling capacity [kW] (unless otherwise specified at 15 °C ambient temperature)
- Mean and peak mass flow H_2 at MPa/min (APRR)
- Ambient temperature
- Refrigerant (e.g.: F-Gas according to European F-Gas Regulation, natural refrigerants GWP <15)
- Pipe length between system and fuel pump [m]
- Explosion/noise protection required?
- Max. overall dimensions
- Interfaces

We would be glad to help you with your design and answer any questions you may have.

LAUDA SUK 350 LN

Indirect dispenser cooling up to 35 kW

Technical data

Application	Cooling for hydrogen refueling stations for T20 / T40 dispenser
Cooling capacity	22 kW at −30 °C HTF outflow temperature
Peak cooling capacity	35 kW (Peak capacity for 1 minute)
Continuous cooling capacity	27 kW at −21.5 °C outflow temperature / 25 °C ambient temperature
Design temperature range	−40 to 50 °C
Operating temperature range	−35 to 40 °C
Heat transfer medium	Aqueous potassium formate solution (HYCOOL 50, Fragoltherm W-FKA)
Flow rate of heat transfer medium	5 m^3/h at 2 bar external pressure drop
Control accuracy	±1 °C (in steady state at a minimum of 10 % load)
Refrigerant (GWP)	R-1270 (GWP 2)
Dimensions (W × D × H)	Approx. 1,500 × 2,690 × 2,820 mm
Installation	Outdoor, access area category C according to EN 378-1
Ambient temperature	−20 to 40 °C
Power supply	400 V; 3/PE; 50 Hz
Max. power consumption	Approx. 40 kW
Max. current consumption	Approx. 65 A
Sound pressure level	Approx. 80 dB(A) in 1 m at full load

LAUDA SUK 400 LNII

Indirect dispenser cooling up to 90 kW

Technical data

Application	Cooling for hydrogen refueling stations for T40 dispenser
Peak cooling capacity for T40 refueling	90 kW
Continuous cooling capacity	40 kW at −42 °C outflow temperature
Design temperature range	−50 to 50 °C
Operating temperature range	−45 to −20 °C
Heat transfer medium	Potassium formate based (e.g. HYCOOL 50)
Flow rate of heat transfer medium	5 m^3/h at 2 bar external pressure drop
Control accuracy	±1 °C (in steady state at a minimum of 10 % load)
Refrigerant (GWP)	1st stage: R-1270 (propene, GWP 2), 2nd stage: R-170 (ethane, GWP 6)
Dimensions (W × D × H)	Approx. 1,400 × 2,980 × 2,700 mm
Installation	Outdoor (optional with C4 protection class)
Ambient temperature	−20 to 40 °C
Power supply	400 V; 3/PE; 50 Hz
Max. power consumption	Approx. 78 kW
Max. current consumption	Approx. 132 A
Sound pressure level	Approx. 75 dB(A) in 1 m at full load

LAUDA DV 400 LNII + Pump module
Indirect dispenser cooling up to 310 kW

Technical data

Application	Cooling for hydrogen refueling stations for T30, H70 / H35 dispenser
Cooling capacity	100 kW at −40 °C
Peak cooling capacity	310 kW (2 chillers + pump module)
Continuous cooling capacity	50 kW (per chiller)
Design temperature range	−50 to 50 °C
Operating temperature range	−45 to −20 °C
Heat transfer medium	Aqueous potassium formate solution (HYCOOL 50, Fragoltherm W-FKA)
Flow rate of heat transfer medium	Approx. 9 m³/h depending on the application
Control accuracy	±1 °C
Refrigerant (GWP)	1st stage: R-1270 (propene, GWP 2), 2nd stage: R-170 (ethane, GWP 6)
Dimensions (W × D × H)	Approx. 1,400 × 2,800 × 2,930 mm
Installation	Outdoor, access area Category C according to EN 378-1
Ambient temperature	−20 to 40 °C
Power supply	400 V; 3/PE; 50 Hz
Max. power consumption	Approx. 95 kW
Max. current consumption	Approx. 160 A
Sound pressure level	Approx. 85 dB(A) in 1 m at full load

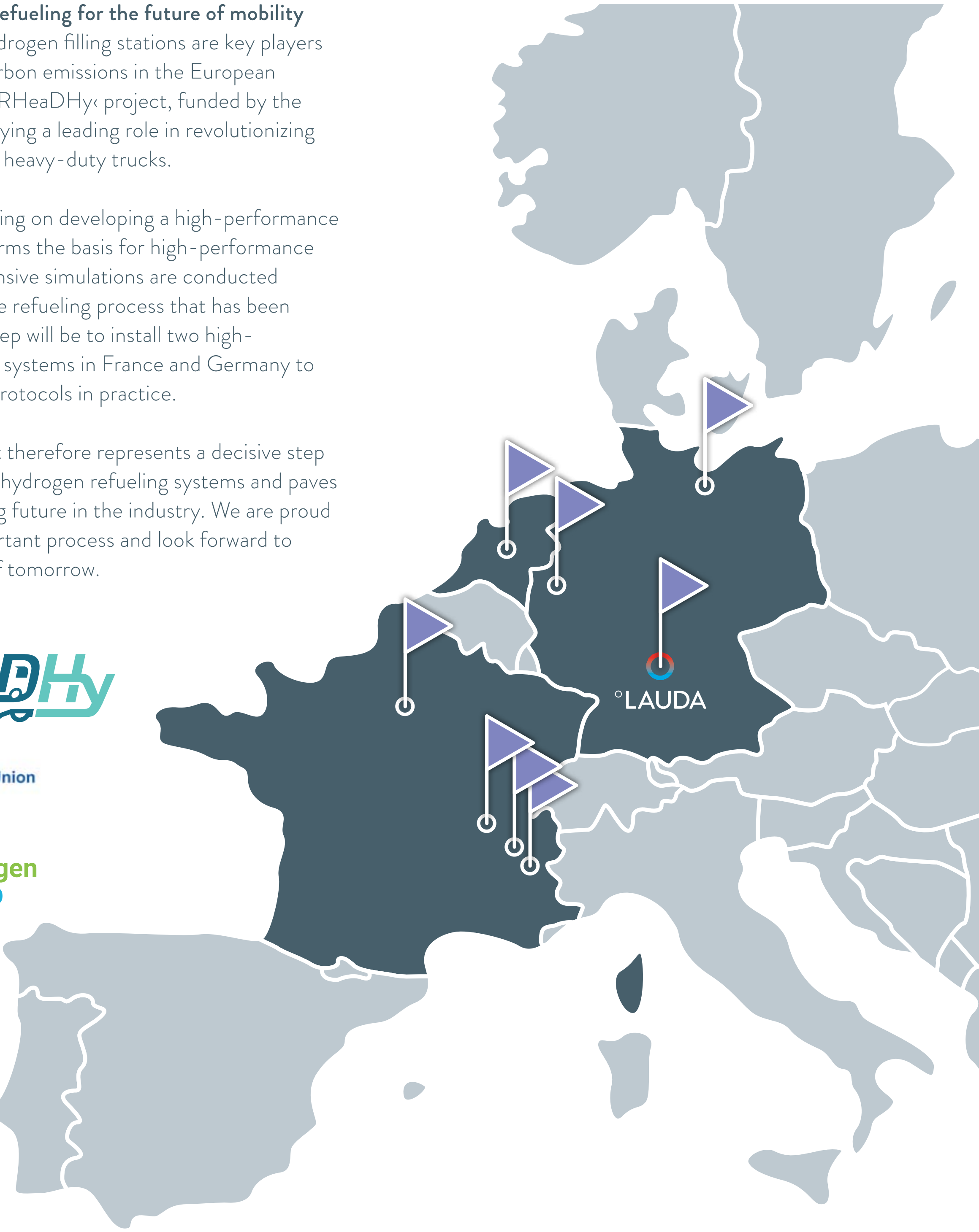
EU PROJECT

RHeaDHy: Research project on the hydrogen refueling of heavy-duty trucks

Pioneering hydrogen refueling for the future of mobility
High-performance hydrogen filling stations are key players in efforts to reduce carbon emissions in the European transport sector. The ›RHeaDHy‹ project, funded by the European Union, is playing a leading role in revolutionizing hydrogen refueling for heavy-duty trucks.

We are primarily focusing on developing a high-performance cooling system that forms the basis for high-performance fueling protocols. Intensive simulations are conducted in advance to verify the refueling process that has been developed. The next step will be to install two high-performance refueling systems in France and Germany to test these innovative protocols in practice.

The RHeaDHy project therefore represents a decisive step in the development of hydrogen refueling systems and paves the way for a promising future in the industry. We are proud to be part of this important process and look forward to shaping the mobility of tomorrow.



RHeaDHy

Funded by the European Union

Clean Hydrogen Partnership

https://rheadhy.eu/

Facts and objectives

- Refueling of long-distance trucks
- H_2 quantity: 100 kg
- Refueling time: 10 min
- Pressure class: 700 bar (H70)
- Flow rates: 170 g/s (300 g/s peak)
- Timeline: February 2023 – January 2027
- Based on PRHYDE

Acknowledgments and disclaimer
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