°LAUDA

GUIDE TO NATURAL AND SYNTHETIC REFRIGERANTS

°FAHRENHEIT. °CELSIUS. °LAUDA.

The global shift towards environmentally conscious refrigeration technology

Reducing the use of F-gases

Whether compact laboratory thermostats or customised heating and cooling systems for plant engineering, LAUDA is leading global supplier of precise energy-efficient temperature control technology.

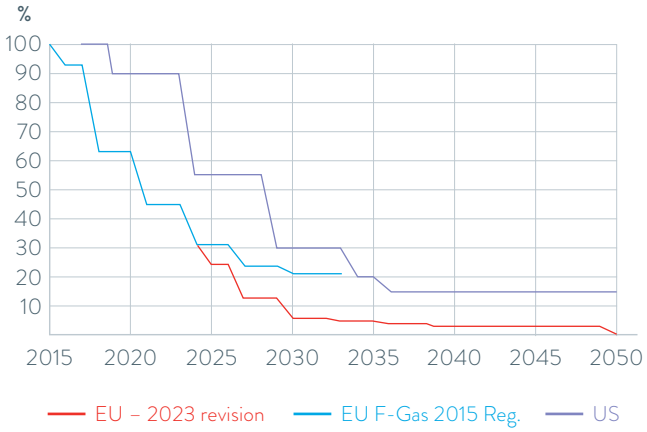
Our equipment and systems are optimised with a focus on high energy efficiency and a lower carbon footprint, as around 95 % of carbon emissions are generated during the equipment's operational life. Whenever possible, we develop our refrigeration systems as standard with electronic control and speed-controlled compressor technology.

LAUDA – Your partner for the global deployment of temperature control technology that complies with regulations

- Equipment using natural and synthetic refrigerants compliant with global refrigerant regulations (EU, UK, USA, Canada, China, Japan, etc.) and export guidelines
- Branches, sales and service partners in more than 150 countries
- Global service for all units using natural and conventional refrigerants
- Special procedures for air transport of urgent equipment containing flammable refrigerants >100 g

An equally central component of our sustainability strategy is the transition of our refrigeration technology towards natural refrigerants, a process we began many years ago. Optimised for specific applications and products, the most suitable refrigerant is used in our temperature control units to continuously reduce the CO_2 footprint in the manufacture and use of our products, in accordance with current regulatory requirements and LAUDA's own sustainability goals.

PHASE-DOWN OF FLUORINATED REFRIGERANTS
(F-GAS QUOTA)



The European Union's F-Gas Regulation, as well as other international regulations such as those of the US EPA, allow for a phased reduction in the use of fluorinated refrigerants with high GWP equivalents, and create a strong incentive to adopt innovative technologies based on natural refrigerants.

A so-called phase-down continuously reduces the market availability of F-gases from a defined reference level by limiting the cumulative GWP = CO_2 equivalent of the F-gases used (the ›F-gas quota‹) that may be placed on the market. Refrigerants with a high GWP are thus subject to supply restrictions and become progressively more expensive.

F-Gas Regulation and US EPA AIM Act

Under the Montreal Protocol and its Kigali Amendment, all countries worldwide have committed to a continuous and legally binding reduction in the production and use of fluorinated refrigerants. Through various implementation groups with individual phase-down curves and timeframes for the phase-out of F-gases, an implementation pathway towards sustainable refrigerants is designed to suit the economic performance of each country.

To reduce the use of fluorinated refrigerants in the European Union and the United States of America, the F-Gas Regulation and the US EPA AIM Act require manufacturers to use natural and synthetic refrigerants with clearly defined GWP limits, specific to each appliance category. For example, air conditioning systems have different limits to ultra-low temperature freezers or coolers.

GWP = Global Warming Potential / CO_2 equivalent

GWP = 5, which means that 1 kg of the refrigerant used corresponds to an emission of 5 kg of CO_2.

The GWP value is a measure of a specific gas's contribution to global warming. Many natural refrigerants, such as CO_2, propane, ethane and many others, have GWP values of <10. New types of F-gas refrigerants, known as HFOs, have GWP values significantly <1,000 and represent a compromise solution. In many applications, they facilitate the transition from conventional F-gases (HFCs) to natural refrigerants.

Placing on the market – limit values

F-GAS REGULATION (EU) 2024/573:

Classification	GWP limit	Cut-off date
Coolers ≤ 12 kW cooling capacity	150	01.01.2027
Coolers ≤12 kW cooling capacity	No fluorinated refrigerants	01.01.2032
Coolers > 12 kW cooling capacity	750	01.01.2027

EXEMPTION FOR THE SEMICONDUCTOR INDUSTRY – IMPLEMENTING REGULATION (EU) 2026/286:

Classification	GWP limit	Cut-off date
Coolers ≤12 kW cooling capacity	150	01.01.2030
Coolers > 12 kW cooling capacity and flow temperature <–50 °C	750	01.01.2030

US EPA AIM ACT:

Classification	GWP limit	Cut-off date
Coolers with a flow temperature –30 °C and above	700	01.01.2026
Coolers with a flow temperature –50 °C and above	700	01.01.2028
Coolers with a flow temperature <–50 °C	n/a	n/a

All LAUDA devices are classified as ›coolers‹ or ›chillers‹ in accordance with the EU F-Gas Regulation and the US AIM Act and are subject to defined marketing bans.

LAUDA solutions at a glance
Natural and synthetic refrigerants

Natural refrigerant
CO_2 powered

R744 is the official designation for carbon dioxide (CO_2) as a refrigerant. R744 is a naturally occurring refrigerant that has no harmful effects on the ozone layer.

It has a very low global warming potential compared to conventional, fluorinated refrigerants, known as HFCs / F-gases. CO_2 or R744 is a non-flammable (A1) refrigerant; however, due to higher operating pressures, it requires adapted components and safety measures.

The natural refrigerant R744 (CO_2) is particularly effective in applications requiring high cooling capacity, indoor installation, flow temperatures below 0 °C, and the use of a central cooling water supply.

Natural refrigerant
Propane-powered

R290 is the official designation for propane as a refrigerant. For LAUDA, R290 is a very important refrigerant due to its low GWP value, its versatility, and its high performance.

Like R744 (CO_2), R290 is a naturally occurring refrigerant. It has no ozone depletion potential (ODP) and a very low global warming potential (GWP of 3). R290 is considered the ideal solution, particularly in refrigeration and domestic appliances such as fridges, air conditioning systems and dryers, but also in industrial refrigeration systems, especially in chemical and pharmaceutical companies, due to its robustness and versatility.

These properties are representative of many other natural hydrocarbon refrigerants, such as R170 (ethane) or R1270 (propene).

The natural refrigerant R290 (and other A3 refrigerants) is characterised by its near 1:1 replacement ratio for fluorinated refrigerants. Indoor and outdoor installation, air- or water-cooled, and high energy efficiency even at flow temperatures > 0 °C make R290 an ideal and more cost-effective solution than R744. Proven and integrated safety features ensure easy use and installation.

Synthetic refrigerant
R513A powered

R513A is a non-flammable HFO/HFC refrigerant blend. It was developed as an alternative to R134A and, with a GWP (Global Warming Potential) of 631, has a significantly lower greenhouse effect than its predecessor (GWP 1,430). As it is designed as a ›drop-in‹ replacement, it can be used in many existing systems without major modifications. Key benefits include lower environmental impact, good energy efficiency and an A1 safety classification (non-flammable, non-toxic).

Synthetic HFO refrigerants such as R513A, which have a lower GWP, represent a good compromise between conventional F-gases (HFCs) and natural refrigerants, and are rightly regarded as transitional refrigerants. A1/HFO refrigerants offer more limited temperature ranges and have lower cooling capacities, but score highly for ease of use. R513A also meets the requirements of the EU F-Gas Regulation (from 12 kW and for export).

Technical comparison
Refrigerants used by LAUDA

	Device with natural refrigerant R744 = CO_2	Device using natural refrigerants / hydrocarbons (e.g. R290 = propane)	Device with HFO refrigerants / synthetic F-gases (e.g. R513A)	Device with HFO refrigerants / synthetic F-gases (e.g. R455A)	Reference: HFC refrigerants / classic F-gases (e.g. R449A)
Safety class	A1	A3	A1	A2L	A1
Toxicity	No	No	No	No	No
Flammability	No	Yes	No	Low	No
Danger of asphyxia	Yes	Low	Low	Low	Low
Specific safety requirements	For installation in cellars or above ground without emergency exits: Minimum room volumes of the installation site and ventilation if necessary (risk of suffocation in the event of leakage).	None up to 150 g refrigerant load. From 150 g refrigerant load: Minimum volumes of the installation location, gas detection sensor and ventilation if necessary.	None	None up to 150 g refrigerant load. From 150 g refrigerant load: Minimum volumes of the installation location, gas detection sensor and ventilation if necessary.	None
GWP (Global Warming Potential = CO_2 equivalent)	1	<10	<1 to <700	<1 to <700	Normally >1,000
COP (Coefficient Of Performance = Ratio of cooling capacity to the electrical power used at full load and tb = 20 °C)	Approx. 3 (single-stage compressor, long-term stability at lower temperatures)	Approx. 3.6 (decreases steadily at lower temperatures)	Approx. 3 (decreases steadily at lower temperatures)	Approx. 3.3 (decreases steadily at lower temperatures)	Approx. 3.3 (decreases steadily at lower temperatures)
Temperature range	Down to −45 °C (single-stage)	Down to −100 °C	Down to −30 °C	Down to −50 °C	Down to −100 °C
Heat discharge	Water-cooled is preferred, air-cooled units show reduced efficiency	Air and water cooling possible	Air and water cooling possible	Air and water cooling possible	Air and water cooling possible
Conclusion	Limited minimum temperature. High energy efficiency and cooling capacity under ideal working conditions (water-cooled, indoor installation). Additional costs due to higher system pressures. Low safety requirements.	Technically ideal replacement for classic F-gases with high energy efficiency. Air and water-cooled design, all temperature ranges can be realized. Established safety technology.	Alternative to conventional F-gases. Advantage in terms of low safety requirements (like HFC refrigerants) and can be designed for air and water cooling, but as a fluorinated refrigerant, its use is restricted in the EU. Limited minimum temperature and lower cooling capacity density require larger systems.	Slightly reduced, but similar safety requirements to natural A3 refrigerants, lower cooling capacity density requires larger systems for comparable cooling capacity.	State-of-the-art technology, high energy efficiency and low safety requirements.

Safe, continuous operation

Integrated safety technology makes the difference

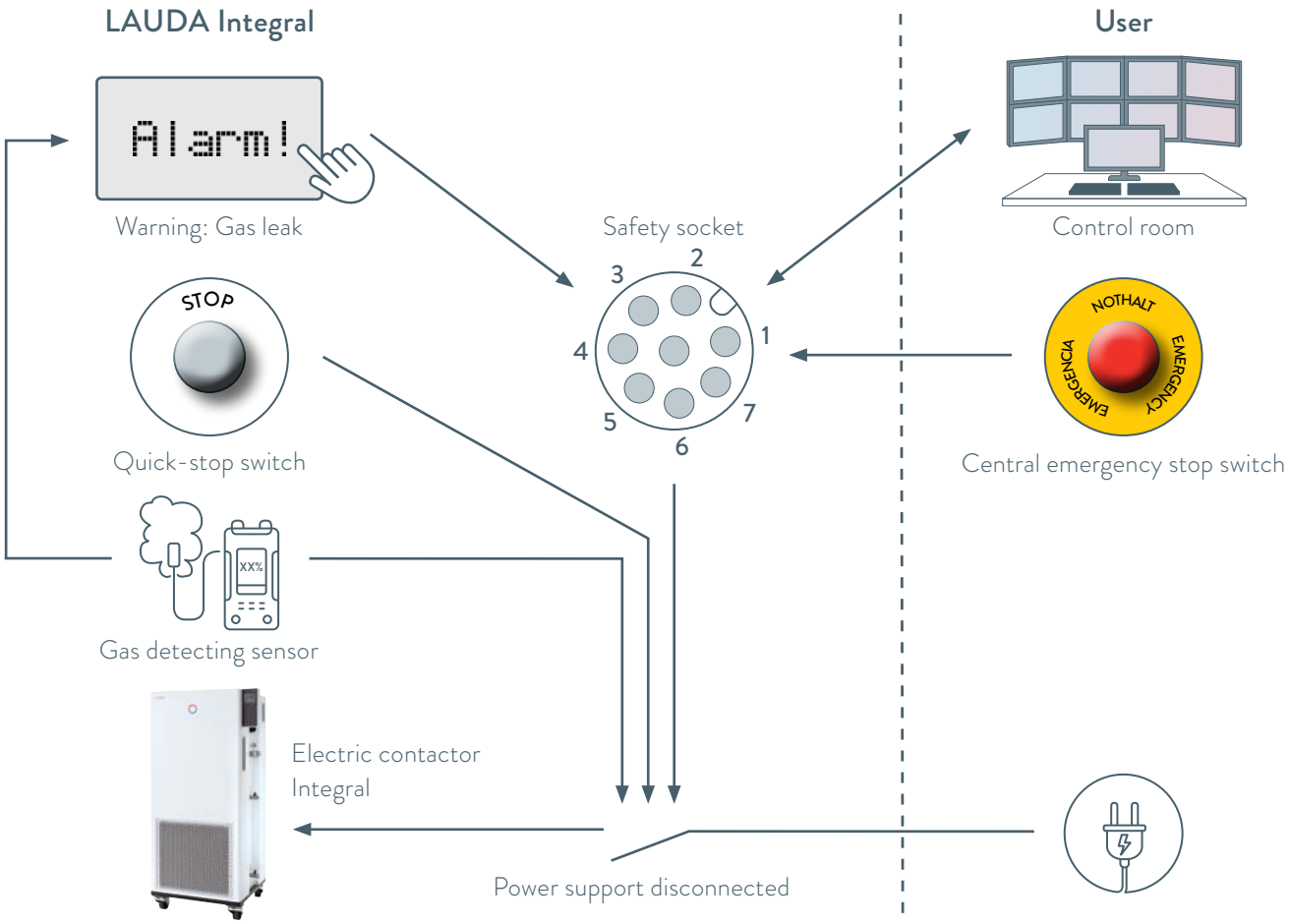
SPECIAL HIGHLIGHTS

Safe, continuous operation
This is the guiding principle behind the integrated safety concept for all LAUDA units containing more than 150 g of A3 (such as propane) and A2L refrigerants. A gas detection sensor, fitted as standard, continuously monitors the surrounding area of the refrigeration system for gas leaks once the unit is connected to the mains supply. The unit can only be switched on if the test is successful. If the leak detection system detects refrigerant during operation, a warning is initially issued depending on the concentration. If the concentration of the refrigerant continues to rise, all components are safely disconnected from the mains.
Special feature of LAUDA Ultracool circulation chillers: Due to the radial ventilation concept, the fan continues to operate even in the event of a gas leak to prevent a critical build-up of concentration.

Up to 15 years without the need for calibration
We support the safe operation of your system through a fully integrated safety concept, saving you the hassle of searching for suitable accessories, selecting the right options and dealing with gas detection sensors that require annual calibration. The devices can be used immediately without any additional retrofitting – provided the minimum room size is observed.

Quick-stop switch and emergency stop
All Integral units containing more than 150 g of CO_2 and A3 refrigerants (e.g. propane) are equipped with a quick-stop switch and an interface for integration into a central emergency stop system.

EXAMPLE SAFETY CONCEPT FOR LAUDA PORTFOLIO UNITS: LAUDA INTEGRAL



Requirements for the installation site

Simple installation and commissioning
LAUDA units using A3 and A2L refrigerants can be installed and used immediately without the need for additional retrofitting – provided the minimum room size is observed – thanks to their integrated safety sensors.

Equipment using CO_2 refrigerant requires particular attention to be paid to the installation conditions and the ventilation system, especially in the case of both underground and above-ground installations in rooms without emergency exits, in order to prevent oxygen depletion in the installation room.

Note: To determine the minimum room size, only the temperature control unit with the highest room size requirement needs to be considered. Values are not cumulative.
Our experts will assist you in selecting the appropriate unit configuration and addressing the requirements of the installation site.
DO YOU HAVE QUESTIONS? WE'D BE HAPPY TO ADVISE YOU PERSONALLY.

EXAMPLE REQUIREMENTS FOR ROOM SIZE AT THE INSTALLATION SITE

Minimum room volume at the installation site = specific room volume per kg of refrigerant** x quantity of refrigerant in kg. The required minimum room volume for refrigerant charges of 150 g or more can be found in the data sheet.

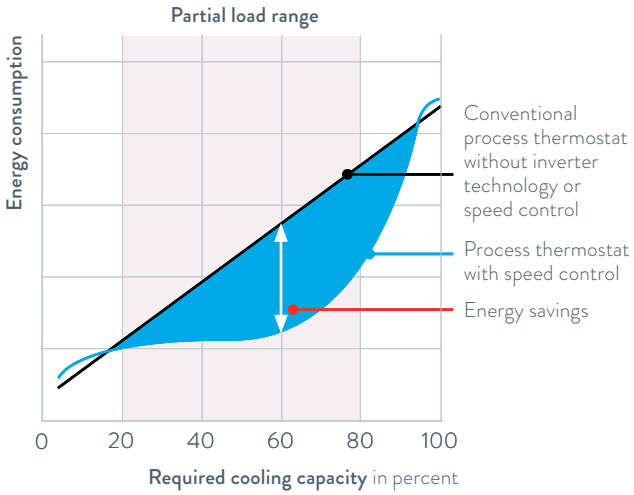
	IN 250 XTW	IN 550 XTW	IN 1850 XTW
Cooling capacity at 20 °C flow temperature	2 kW	5 kW	20 kW
Refrigerant quantity	<150 g	R290 (GWP 3); 0.450 kg; 1.35 kg CO_2-eq	R1270 (GWP 2); 0.925 kg; 1.85 kg CO_2-eq
Minimum room size*	No requirement	59.4 m³	100.8 m³

* Room volume per kg of refrigerant according to DIN EN 378-1. This standard applies to the EU. The ISO 5149-1 standard applies worldwide.
** Specific room volume depends on the type of refrigerant

Refrigeration technology in change: efficiency as the benchmark

Our units and systems are optimised with a focus on energy efficiency and a lower carbon footprint. Wherever possible, we develop our cooling systems as standard with electronic control and speed-controlled compressor technology. High-performance circulation chillers such as the LAUDA Ultracool achieve energy savings of up to 50 % compared to conventional technology without inverter technology or speed control, whilst high-precision LAUDA Universa bath thermostats achieve savings of up to 78 %. We continuously strive to meet these high standards, from laboratory equipment to process thermostats in production.

ENERGY EFFICIENCY IN THE PARTIAL LOAD RANGE



As virtually all applications and cooling processes operate in a partial load range for the majority of the time, speed-controlled compressors offer energy efficiency at the highest level.

COP = COEFFICIENT OF PERFORMANCE (COOLING CAPACITY/ELECTRICAL POWER CONSUMPTION)

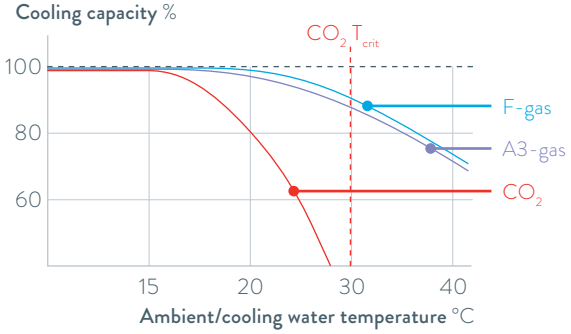
USING THE INTEGRAL 2040 XTW (REFRIGERANT CO_2) AS AN EXAMPLE

Temperature °C	Cooling capacity kW	COP
20	20.8	2.5
10	20.5	2.4
0	17.8	2.1
–10	14.0	1.7
–20	10.5	1.5
–30	6.6	1.1
–40	3.5	0.7

The COP is a useful parameter for comparing refrigeration units that operate statically at a defined setpoint. LAUDA process thermostats often have to operate dynamically across a wide temperature range with a variety of changing setpoints in countless applications. Comparing COP values therefore requires a detailed examination of the specific application scenarios in order to draw conclusions about energy efficiency.

EFFICIENCY OF REFRIGERATION TECHNOLOGY –

INFLUENCE OF COOLING WATER AND AMBIENT TEMPERATURE



CO_2 refrigeration systems operate at high capacity and efficiency at low ambient and cooling water temperatures. However, this decreases substantially when the cooling water temperature exceeds 20 °C. A3 refrigerants such as propane behave similarly to conventional F-gases and continue to operate powerfully and efficiently even at a cooling water temperature of 30 °C or an ambient temperature of 40 °C. High energy efficiency must be assessed across the entire installation system.

Logistics requirements depending on the refrigerant used

Transport by	Freon/F-Gas	Natural refrigerant – A1 (CO_2)	Natural refrigerant – A3 (Propane, Ethane, etc.)	HFO – A1 refrigerant	HFO – A2L refrigerant
Road	Yes*	Yes*	Yes, up to 12 kg refrigerant load	Yes*	Yes*
Air	Yes*	Yes*	Yes, up to 100 g refrigerant load**	Yes*	Yes, up to 100 g refrigerant load**
Sea	Yes*	Yes*	Yes*	Yes*	Yes*

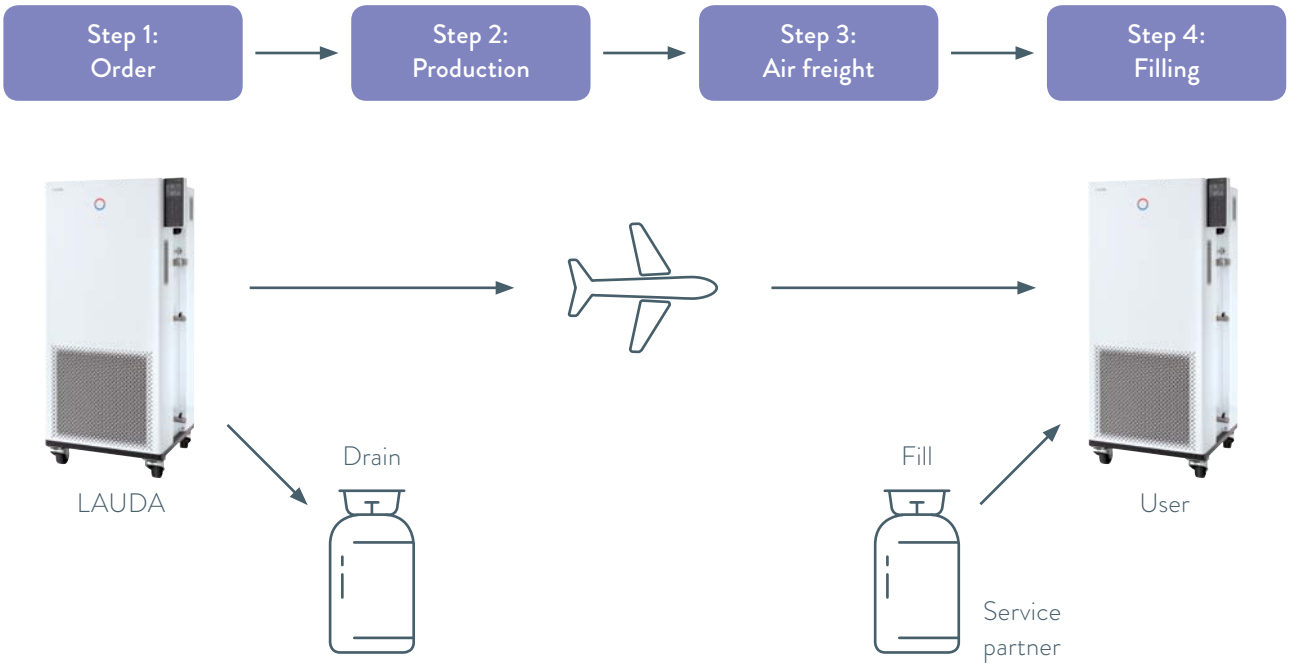
* Additional delivery documentation required for systems with >12 kg refrigerant load, e.g., high-performance industrial systems in the field of plant engineering.
** LAUDA offers special logistics and service processes for urgent transportation of appliances with >100 g refrigerant (class A3 and A2L) via air freight.

Local regulation may impose stricter limits or add additional parameters. Please verify your legal obligations. Any violations on logistic regulations are within the shippers sole responsibility if transport is not undertaken by LAUDA.

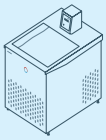
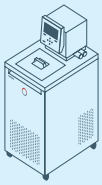
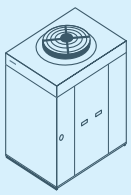
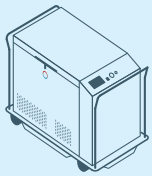
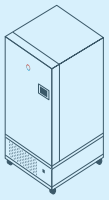
LAUDA units containing flammable refrigerants are subject to UN number UN 3358. Air freight transport is regulated by the IATA regulations. Special provision A103 of the IATA regulations applies to UN 3358.

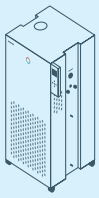
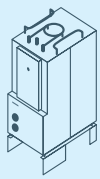
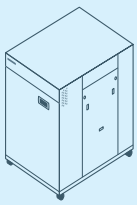
According to this special provision, units filled with < 100 grams of gas (refrigerant) are not classified as dangerous goods within the meaning of the regulations.

PROCESS FOR URGENT INQUIRIES DEMANDING AIR CARGO



LAUDA units with natural and synthetic refrigerants

	Device range	Device type	Refrigerant per refrigeration circuit	Quantity	Gas sensors	Airworthiness
	BATH THERMOSTATS					
	**Alpha**	All	A3	<100 g	Not necessary	Yes
	**Universa**	All	A3	<100 g	Not necessary	Yes
	CIRCULATION CHILLERS					
	**Microcool**	All	A3	<100 g	Not necessary	Yes
	**Ultracool**	UC 2 - UC 100	A3	>150 g	Yes	No
	DEEP-FREEZERS					
	**Mobifreeze**	All	A3	<150 g	Not necessary	No
	**Versafreeze**	All	A3	<150 g	Not necessary	No

	Device range	Device type	Refrigerant per refrigeration circuit	Quantity	Gas sensors	Airworthiness
PROCESS THERMOSTATS						
	**Integral**	IN 1040 / 2540 / 3540 XTW	A1 (R744=CO_2)	>150 g	Not necessary	Yes
		IN 550 / 750 / 950 / 1850 XT / XTW	A3	>150 g	Yes	No
	**LOOP**	All	Peltier technology	Not applicable	Not applicable	Yes
	**PRO**	All	A3	<150 g	Not necessary	No
	**Semistat**	All	Peltier technology	Not applicable	Not applicable	Yes
	**Ultratemp**	UT 2505 / 3505	A1 (R513a)	Not applicable	Not necessary	Yes
		VC 1200 / 2000	A3	<100 g	Not necessary	Yes
	**Variocool**	VC 5000 / 10000 US voltage (60 Hz)	A1 (R513a)	Not applicable	Not necessary	Yes
		VC 5000 / 10000 EU voltage (50 Hz)	A3	>150 g	Yes	No

LAUDA DR. R. WOBSER GMBH & CO. KG
Laudaplatz 1 • 97922 Lauda-Königshofen • Germany
www.lauda.de

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