INDUSTRIAL REFRIGERATION

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30160691 04/12

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ENGLISH

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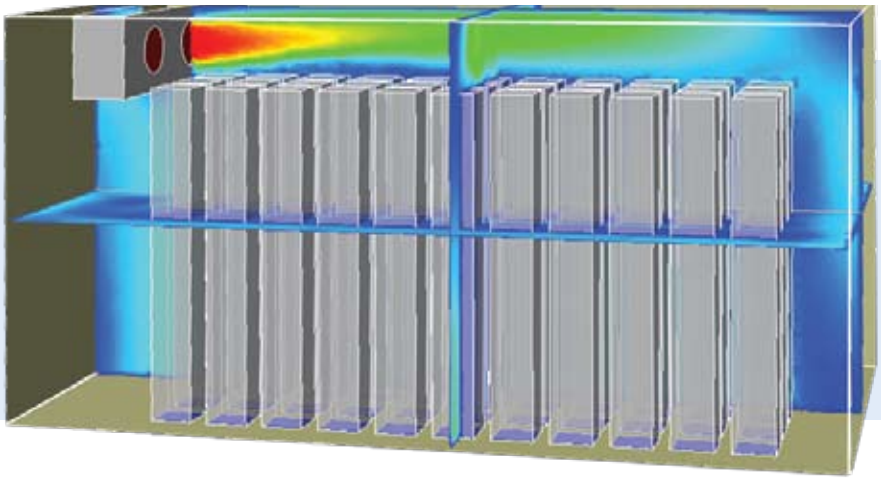
Refrigeration is the technique which allows mankind to store food products and easily retrieve them in times and places that are different to the ones in which they were harvested and processed.
There are very many different fields in which the techniques of refrigeration can be applied.

The choice of equipment type, the way it distributes the refrigeration, the quantities of air necessary for properly storing the goods, can all prove to be vastly different depending on the different operating conditions. A careful analysis of the various parameters has to be carried out so that the best-suited product for a particular use can be chosen. During the many years of its activity, LU-VE has accumulated considerable experience in the sector, developing products that are capable of satisfying different operating requirements.
The criteria for classifying the various types of equipment and refrigeration needs can be:

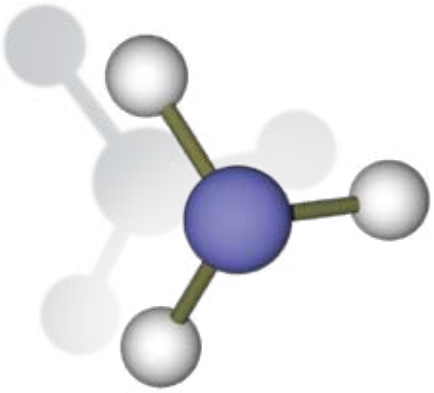
- **Storage of fresh products**
- **Storage of packaged products**
- **Storage of frozen products**
- **Storage/rapid temperature reduction (chilling)**

Cold room:
dimensions, goods loading procedures and storage duration

Refrigeration includes goods storage types that are very different to each other. They vary from small- and medium-sized cold rooms to very large refrigerated warehouses (typical of the logistic hubs of large distribution chains) which can be even more than 100m long.
In addition, there may be a rapid turnover of goods in cold rooms or the goods may be stored there for many months, up to almost a year for fruit storage in a controlled atmosphere.
LU-VE uses a sophisticated CFD software simulation system in order to estimate more precisely both the various requirements and correct air distribution on the inside of the cold room. It also guarantees a high level of homogeneity as regards air thermal and hygrometric conditions. The software allows both air cooler choice and positioning to be optimised, as well as enabling the evaluation of the effective distribution of the air flows that refrigerate the goods.



Operating liquid



Operating liquids can all be very different to each other, and they have a significant impact on the choice of both the unit cooler and the materials used to construct the heat exchanger. The following are the main liquids for which LU-VE proposes specific product ranges.

HFC R404A, R507A, etc;

Ammonia (NH_3)

Single-phase liquids
ethylene or propylene glycol, potassium acetates, etc.;

CO_2
with different levels of maximum operating pressure.

The solution proposed by LU-VE for ammonia unit coolers proves to be particularly efficient and can noticeably reduce the refrigerant charge compared to traditional solutions using 5/8" or larger diameter tubes. Comparing two unit coolers of equal capacity, the LU-VE standard and one with 5/8" tubing, a 30% reduction of internal volume was found. In large systems this can lead to a major re-sizing of the ammonia charge and to a real reduction in the size of the main NH3 tank with a consequent dramatic fall in total system liquid charge. The system would also be classified differently from a regulatory point of view depending on the ammonia charge.

Environmental conditions: material resistance

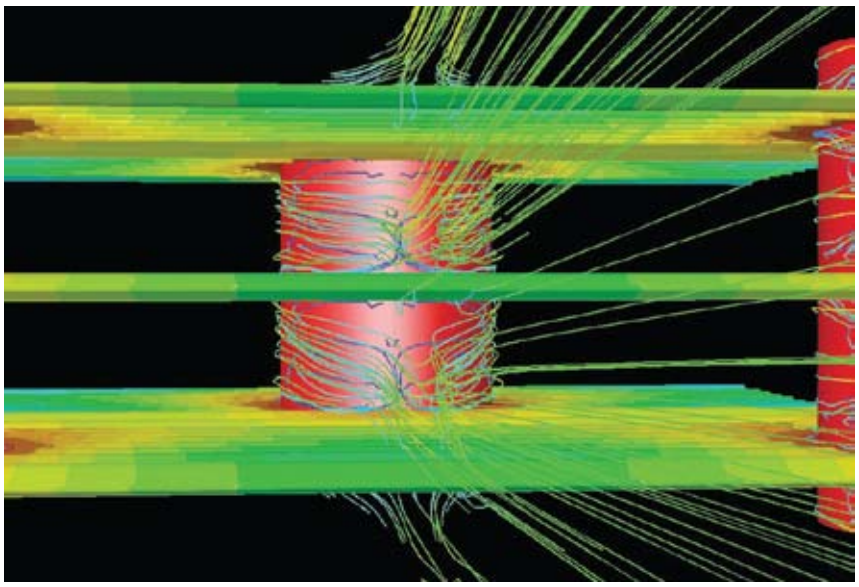
Some storage processes (e.g. cheese maturing, leather storage etc) generate substances that attack the materials traditionally used to make standard products (copper tubes, aluminium fins, zinc-plated casings). In other cases it is the periodical sanitisation process of the storage area and the air cooler that can prove to be aggressive.
In these circumstances special equipment is available that has the following characteristics:

- **Coated aluminium fins (Alupaint®)**
- **Copper fins**
- **Stainless steel tubes**
- **Heat exchangers painted using various protective treatments "Blygold", "Heresite"and cataphoresis**
- **Heat exchangers with tubes and fins in electrolytic tin-plated copper**
- **Stainless steel casings**

Please contact the LU-VE offices for a precise analysis of the various solutions available, bearing in mind that all of the above solutions may not be available for all models due to process-related size restrictions.

Frosting: choosing fin geometry and pitch

The need to guarantee a more or less prolonged defrosting period and therefore a longer cooling operating period, are the basic criteria for defining heat exchanger geometry, primary and secondary surface ratio, and fin pitch.



CHS Compact Hitec Surface

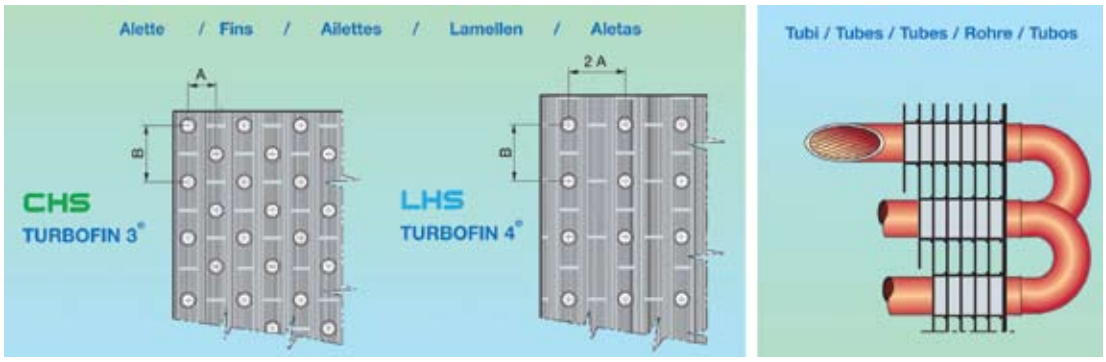
Turbofin® 3 Fins

The heat exchanger **CHS**, with staggered rows, equipped with the new **Turbofin® 3** fin, is characterised by an optimal ratio between secondary fin surface and primary surface of the tubes ensuring very high unitary capacities.
The elevated thickness aluminium fins have an optimised configuration for industrial refrigeration applications.
The **CHS** unit coolers find the best application in both high and low temperature applications for the conservation of products with low humidity content or packed products that accept an even higher difference between room temperature and refrigerant temperature.
The defrost of the unit coolers is facilitated by the minimum quantity of frost on the fins which are defrosted with reduced amount ofenergy.

LHS Large Hitec Surface

Turbofin® 4 Fins

The heat exchanger **LHS**, with in line rows conceived with the new **Turbofin® 4** fin is characterised by a high ratio between secondary fin surface and primary surface of the tubes that ensures, with the same primary surface, a higher capacity than the one obtained on the CHS heat exchanger.
The elevated thickness aluminium fins have twice the surface of the CHS unit coolers and are designed witha special configuration to cope with large formation of frost.
The **LHS** unit coolers are most suitable for high and low temperature applications for the conservation of high humidity products and for freezing.
For these applications the combinations of large fin spacing and large fins surface ensures longer intervals between defrost cycles and an elevated air throw.

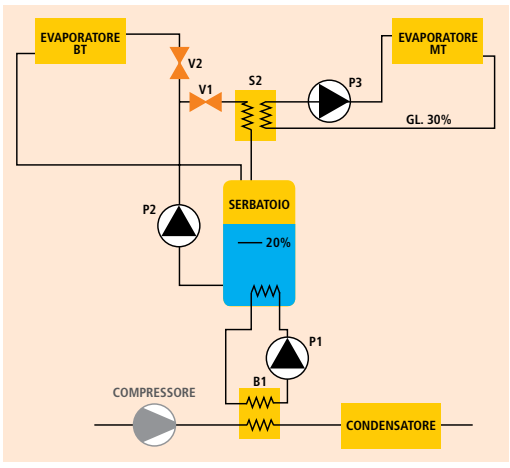


Defrosting

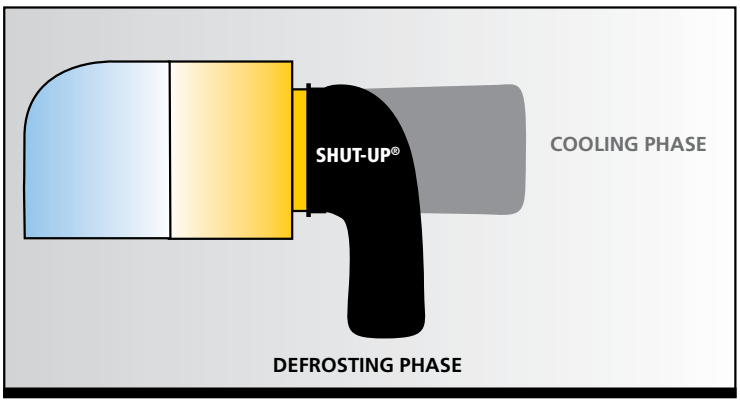
During equipment operation with a cold room temperature of around or less than 0°C, frost deposits are formed on the fins in a more or less widespread manner, thus requiring the installation of a defrosting system. LU-VE can offer several solutions capable of satisfying different system requirements.

- **Electrical defrosting**
- **Hot gas defrosting**
- **Water defrosting**
- **Hot glycol defrosting**

This last solution entails installing a circuit within the heat exchanger (separate from the refrigeration circuit) in which hot glycol water flows during defrosting. This configuration proved to be very favourable from an energy point of view, recovering the heat already available within the system (generally from refrigerant condensation). Compared to traditional electrical defrosting this solution allows large energy savings to be made and payback generally occurs within 18 months. See the general system layout diagram.



Layout



In low temperature storage cold rooms, defrosting efficiency becomes very important in order to avoid introducing heat to the cold room which will then have to be removed again by the refrigerating system. Furthermore, the loss of vapour from the equipment also leads to a dangerous formation of condensation and therefore to ice formation on the cold room roof and floor. Solutions are available for reducing these problems by closing the discharge fan outlet and the air intake side by means of air director cover or motorised shutters (available for temperatures down to -30°C).

Air director cover

Shutter

Specific products for different applications

LU-VE has a vast range of standard industrial unit coolers that are suitable for satisfying most industrial refrigeration installation requirements. LU-VE considers one of its strengths to be its ability to help both the refrigeration engineer and designer choose the best product for a specific refrigeration installation.

In this section, several special applications are listed in which, besides the already-mentioned standard equipment, LU-VE can offer special solutions that are capable of satisfying specific needs.

Fresh fruit and vegetable storage

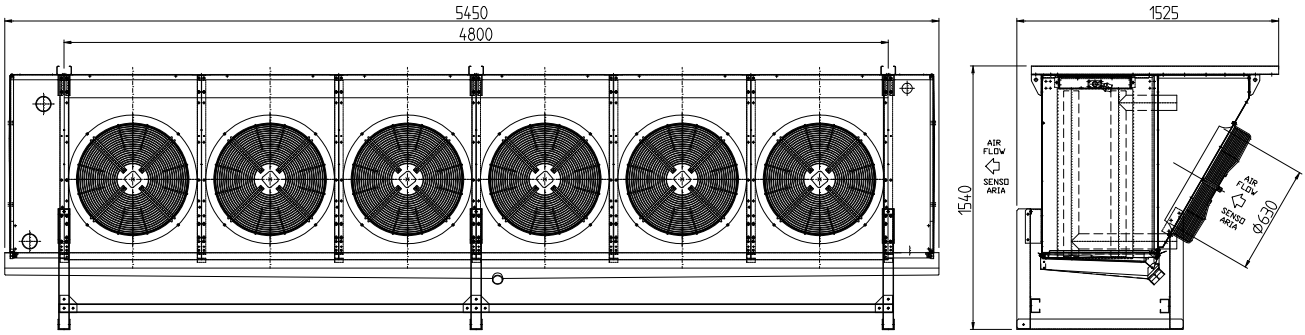
This is a very special field in which very delicate living products are processed, which have to be stored sometimes even for many months.

Since the main objective of an air cooler is to minimise any product weight loss due to product dehydration, then it is fundamental to operate with very low temperature differences between air and refrigerating liquid.
If we are considering cold storage rooms for very long periods in a controlled atmosphere with reduced oxygen (O2) percentage levels in the air, then it can be particularly advantageous to use blower fan air flows, i.e. with the fan placed up-stream of the heat exchanger. In this way (as can be seen from the drawings in page 8) the air is heated by the motor before it is cooled down by the heat exchanger. This means that (for identical air cooler output air temperatures) the product being stored needs less dehumidifying and therefore less drying.

STORAGE PROCEDURES FOR DIFFERENT TYPES OF FRUIT AND VEGETABLES

	Fresh product conservation temperature	Fresh product conservation relative humidity	Freezing temperature	Frozen product conservation temperature
	°C	%	°C	°C
Pineapples	7	87	-1,5	-18
Oranges	0,5	87	-2,2	-18
Bananas	14	90	-2,2	-18
Cherries	-0,5	86	-2,2	-18
Dates (dried)	-1,5	70	-15,5	-18
Strawberries	0	86	-1,1	-18
Lemons	9,5	87	-2,2	-18
Tangerines	5	87	-2,2	-18
Apples	0,5	87	-2	-18
Melons	6	87	-1,4	-18
Pears	-0,5	87	-1,9	-18
Peaches	0	87	-1,5	-18
Grapefruit	5	87	-2	-18
Prunes	0	87	-2,2	-18
Grapes	-0,5	87	-3	-18
Avocados	7	90	-0,3	-25
Persimmons	-1	90	-2,2	-25
Citrons	7	87	-1,5	-25
Kiwi	4	93	-0,9	-25
Raspberries	-0,5	85	-1,1	-28
Limes	9	87	-1,6	-28
Mangoes	13,7	93	-0,9	-28
Cranberries	2	85	-2,5	-25
Nectarines	-0,5	87	-0,9	-28
Beetroots	0	92	-0,5	-18
Cauliflowers	0	92	-1,6	-18
Artichokes	0	92	-1,7	-18
Carrots	0	90	-1,4	-18
Califlowers	0	87	-0,5	-18
Cucumber	8	92	-0,8	-18
Onions	-1	72	-1,1	-18
Beans (fresh)	5	87	-1,2	-18
Beans (dried)	4	70	-9,9	-18
Mushrooms	0,5	87	-1	-18
Lettuce	0	92	-0,5	-18
Potatoes	6	87	-1,7	-18
Peas (fresh)	-0,5	87	-1,1	-18
Peas (dried)	4	70	-9,9	-18
Tomatoes (red)	8	87	-0,5	-18
Tomatoes (green)	12	87	-0,5	-18
Celery	-0,5	92	-1,3	-18
Spinach	-0,5	92	-0,9	-18

To allow, therefore, more favourable air circulation within the cold room and more free space dedicated to the goods, LU-VE has developed an innovative product called “Value Defender” with an inclined fan. This solution should be used when the refrigerating liquid is single-phase (glycol-water or similar) which is a very frequent condition in this field. It allows the temperature difference between the air and the tube liquid to be reduced to a few degrees.

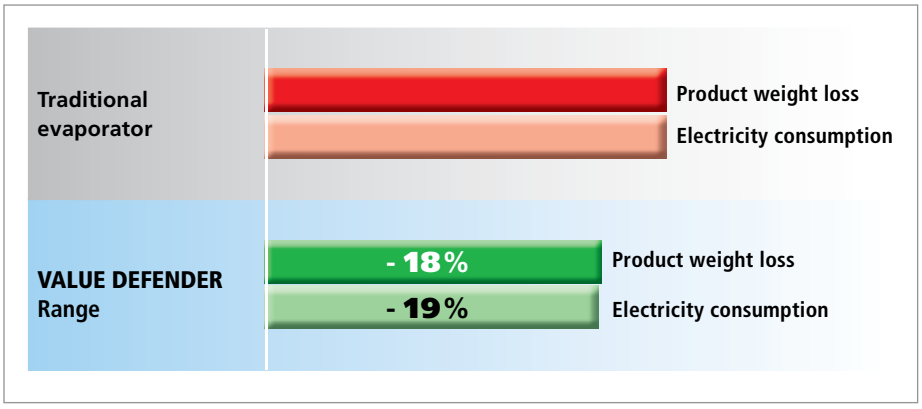


The “VALUE DEFENDER” range is available in a number of possible configurations, see table below (rough guide):

VALUE DEFENDER air coolers			
		min	max
Capacity (fin space 6mm)	kW	5	100
Number of fans		2	6
Fan diameter	mm	450	800
Fin space	mm	6	7,5

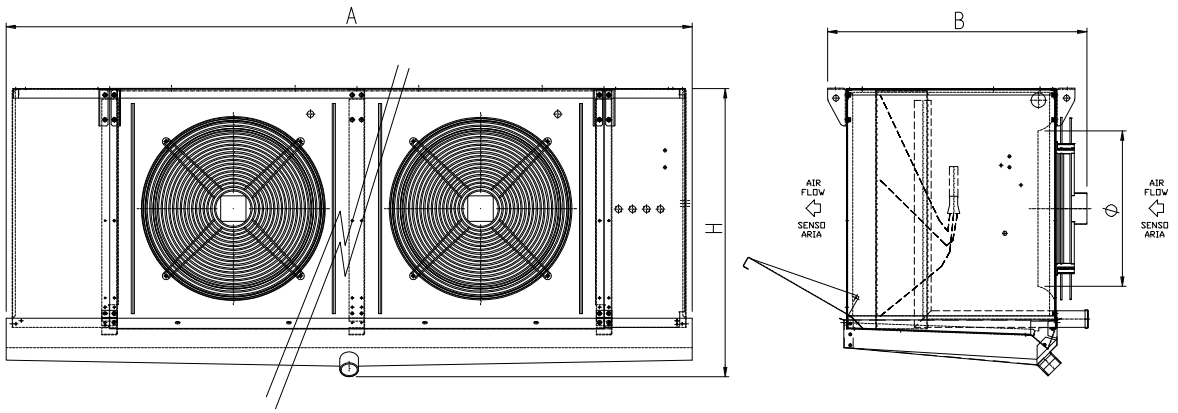
Capacity refers to:
Cold room temp. +1°C; glycol liquid 30%; glycol temp. -5 / -2°C

In-depth comparison tests were carried out on controlled atmosphere apple cold storage rooms in the Trentino region of Italy and they showed that compared to a traditional suction fan cubic unit cooler, the “Value Defender” configuration allows the goods weight loss to be reduced by 18% and to reduce ventilation electricity consumption by 19%.



Cubic blower fan configuration

A cubic blower machine configuration is also available and is advised for direct expansion HFC refrigerant applications.

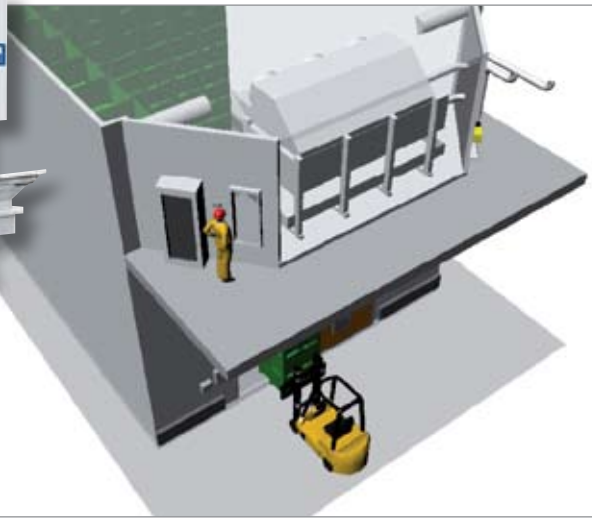


PDF range

Another possible product configuration is the PDF range which has a horizontal heat exchanger and is recommended for cases in which a space is available for installing the air cooler. In this way one obtains a type of technical room in which it is easy to access the machinery and at the same time the available volume for storing goods in the cold room is increased.

PDF model

Possible layout for a PDF model (fresh fruit storage)



Performance levels of the PDF shown are:
Capacity 116kW with glycol-water at 30%;
Cold room temperature: +1°C

Meat cold rooms

There are two main types of cold room:
- product cold storage rooms
- product processing cold rooms
  (with a varying number of operators present).

Some indicative **meat storage** cold room parameters:

SUGGESTED VALUES FOR GENERIC COLD STORE				
Cold storage room type	RT [°C]	r.H. [%]	Number of recirculation	DT1 [K]
Cold storage room (multipurpose use)	0/+2	80	≈ 30	7
Arrival cold store	0/+2	85	50 ÷ 100 normal ≈ 75	7
Fast cooling for pork	0/+2	90	150 ÷ 250 normal ≈ 200	7
Fast cooling for beef	0/+2	90	150 ÷ 250 normal ≈ 200	7
Sausage meat	0/+2	85	≈ 30	7
Cooling down "wet" (sausage)	0/+2	90	30 ÷ 75	7
Cooling down "dry" (sausage)	0/+2	80	≈ 30	7
Pickle room	0/+2	85	≈ 30	7
Gut stock	0/+2	80	≈ 30	7
Slaughterhouse waste	0/+2	80	≈ 30	7
Preparation	+2/+4	80	≈ 30	8
Precooling	+4/+6	80	≈ 30	9

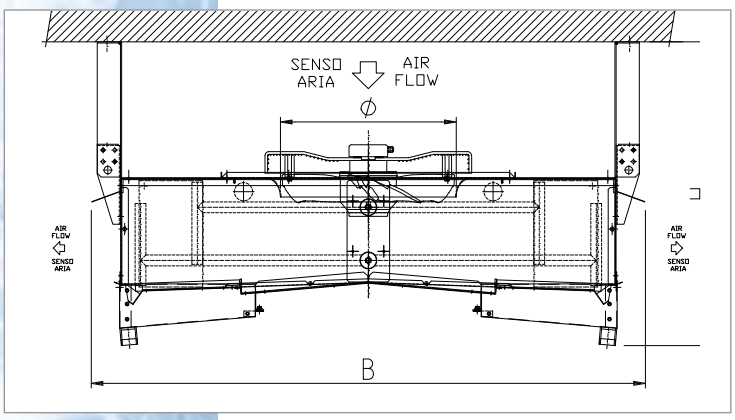
Some indicative **meat processing** cold room parameters

Workroom type	RT [°C]	r.H. [%]	DT1 [K]
Workroom, normal for several uses	+10/+12	80	9
Workroom, advanced for several uses	+8/+10	80	7
Cooling down "wet" (sausage)	+12/+14	85	10
Pickle room	+10/+12	80	9

These are cold rooms in which defrosting is not envisaged although, on the other hand, low air speed and limited noise levels are important in order to safeguard operator health. Double flow category equipment is often used and is available either in the normal or silent version (CDH range).

Standard CDH model

CDH TOP FAN



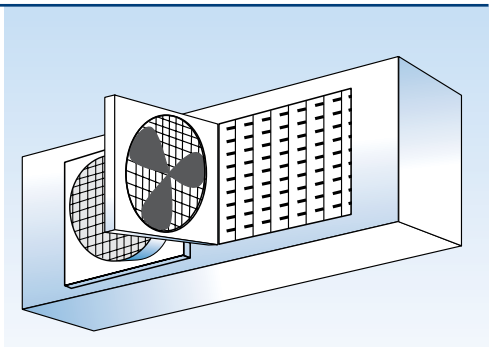
There is also a special variant in which the fan is located on top of the unit. Here the air speed perceived by operators is less, the downside being that the heat exchange efficiency is slightly reduced and the space use in terms of height is about double that of other units. The latter variant can be seen below complete with a stainless steel enclosure and copper fins, installed in a cold room for maturing prosciutto hams.

The CDH TOP FAN is available with 1 to 4 fans, fan diameter 450 mm.
Contact LU-VE for further information.

During meat processing, hygiene is a very important aspect. The following factors must be given careful consideration:

- easy surface cleaning
- accessibility
- surface resistance to corrosive phenomena (induced by substances used to clean unit coolers).

Special solutions developed by LU-VE such as stainless steel casings and total heat exchanger accessibility (even from the ventilation side due to easy-to-open fan shrouds) have all proved extremely useful from a hygiene point of view.

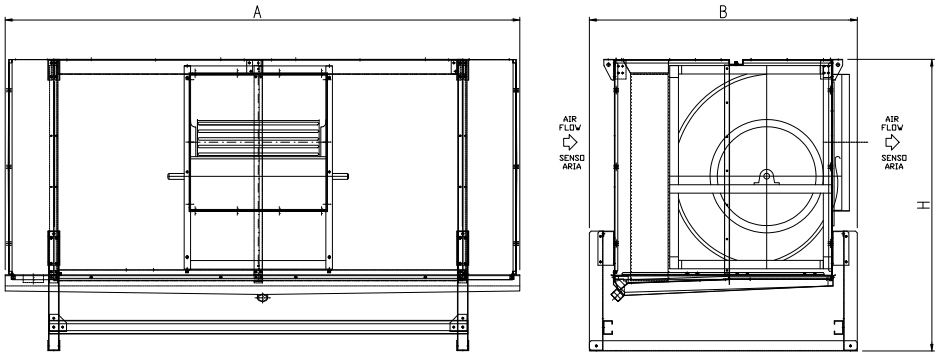


Easy-to-open fan shrouds

Unit coolers with centrifugal fans

Centrifugal cooler (1 fan)

There are numerous installations (for example in the cake- and bread-making sector) where cooling at temperatures of around +10 ÷ 15°C is required in the cold rooms in which the product is being processed and this is provided by a ducted air distributor system. The standard range of unit coolers already has numerous versions with fans capable of supplying a generous level of residual static pressure (up to about 100Pa). If higher values are necessary, then it is possible to supply unit coolers with centrifugal fans that can go above even 400Pa. A specific range of products has been designed for this purpose, with impellers of various diameters, examples of which can be seen below.



UNIT COOLERS WITH CENTRIFUGAL FANS					
			Configuration 1	**Configuration 2**	**Configuration 3**
Capacity (fin space 4.5mm)		[kW]	30 ÷ 38	35 ÷ 45	50 ÷ 90
Residual static pressure		[Pa]	100 ÷ 200	100 ÷ 200	100 ÷ 300
Dimensions	A	[mm]	1850	1850	3050
	B	[mm]	1300	1300	1575
	C	[mm]	1400	1650	1750

Capacity refers to machines with 1 fan, cold room temperature +2.5°C, ΔT1=10K; R404A

The table and the design of the range of unit coolers with centrifugal fans refers to models with one fan; versions with more than one fan are also available.

Logistic hubs

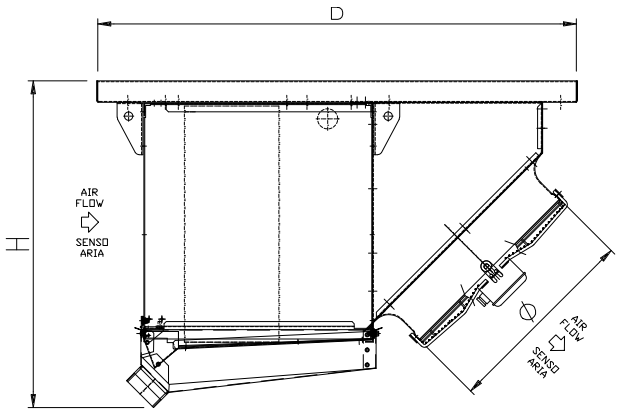
The strong growth in large scale retail trade has given rise to large refrigerated warehouses where goods (mostly packaged) are stored for short periods while awaiting to be delivered to various sales outlets.

These can be hubs that store either fresh or deep-frozen products. In these configurations unit coolers are required to have the capability of guaranteeing an adequate circulation of air even for cold rooms which are over 100m in length.

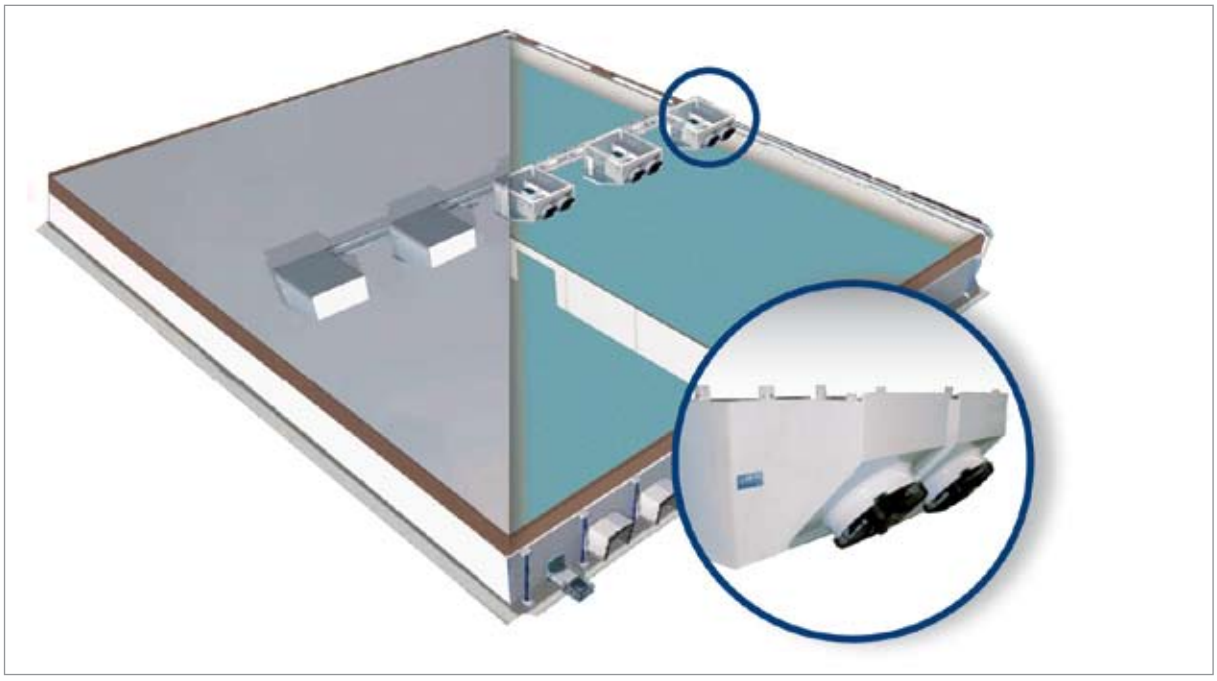
It is quite common to use glycol-water air coolers for cold rooms with a temperature of 0 ÷ +4°C, whereas the use of CO2 is becoming increasingly attractive for deep freeze product cold rooms.

Unit coolers with inclined (45°) fan shroud

As shown in the images below, the configuration of a unit cooler with 45° inclined fan shrouds allows it to be installed outside the cold room. It therefore does not take away space from goods or impede their movement in any way, especially in highly-automated warehouses. Furthermore since the heat exchanger is outside the cold room it is totally accessible.



The performance levels of the inclined unit coolers largely follows that of the CS/LS range from which it derives.



Layout

Fast deep freezing/cooling

The last few years have witnessed an exponential development in demand for precooked or deep-frozen foods, and hence the development of numerous systems for rapidly cooling and/or freezing food products.

As regards this, LU-VE is currently offering a large range of solutions capable of satisfying the most divergent and varied system requirements

Cubic unit cooler solutions (CHS/LHS range)

A deep freeze system can use cubic unit coolers (in a plant layout as shown in Fig.1) that are either standard or have strengthened fans (Fig.2)

Cubic unit cooler (operating diagram)

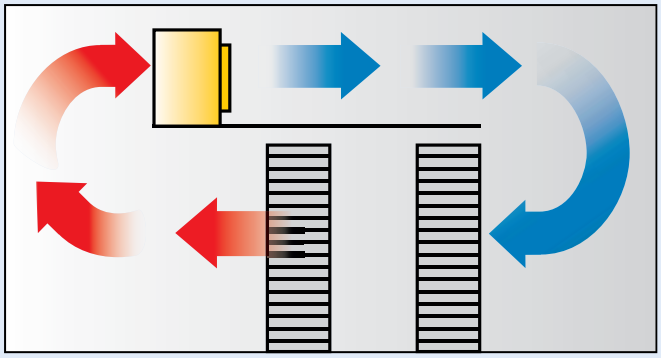


Fig. 1

Unit cooler with reinforced fans

Fig.2

In fact the CHS/LHS range of cubic unit coolers is available, also with special fans fitted, and is capable of supplying the air flow rate and static pressure required for the specific implementation type. Fig. 2 shows a machine fitted with a fan group each of which is capable of supplying 30.000 m3/h with 100Pa of residual static pressure, almost double the performance of the standard range fan.

Fast Freezer (FF) range

The FF range (see Figs. 3 and 4), fitted with high residual pressure blower fans, is suitable for tunnel freezers where it is necessary to blast a strong flow of cold air directly onto the product to be cooled, ensuring that the air flow itself is highly homogeneous.

FAST FREEZER

Fig. 3

Operating diagram

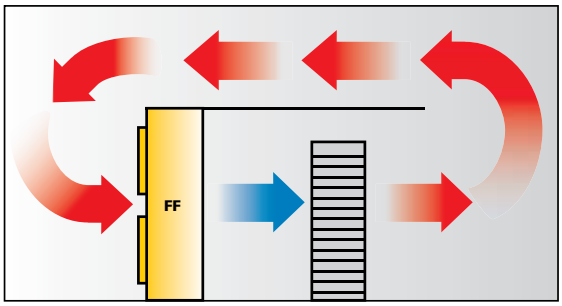
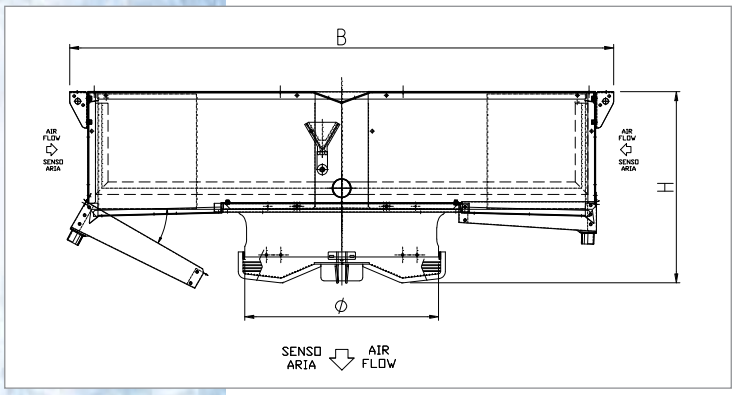


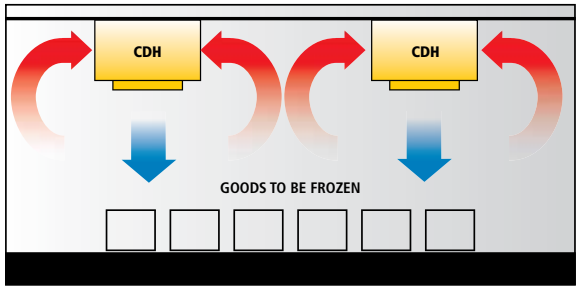
Fig. 4

Inverse flow CDH range

LU-VE suggests that the double flow unit cooler configuration with side air intake and downwards flow be used in systems in which the goods to be rapidly cooled are on the conveyor belt underneath the equipment, thereby achieving very rapid processing. The entire CDH range is available in this configuration, even with quadruple type LHS geometry, whenever long defrosting intervals are required and operation entails a large quantity of frost being accumulated on the fins.

CDH

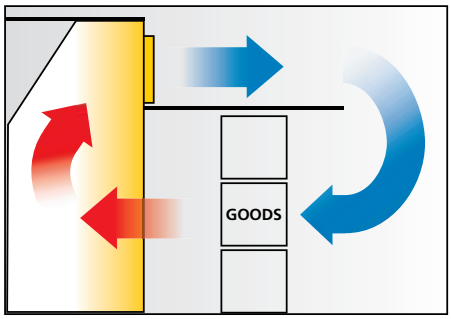




Inverse flow diagram

Tunnel unit cooler range (medium capacity)

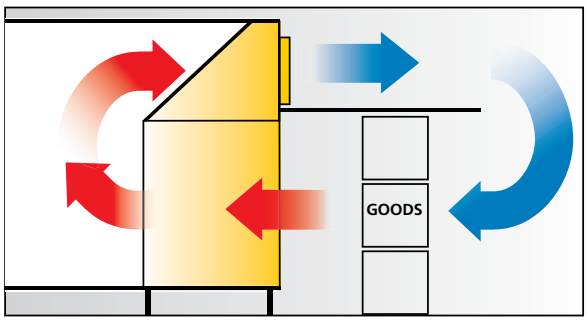
This range allows the air flow to be split into two levels, the lower one crosses over the product to be cooled, and the upper one (separated by a false ceiling in the cold room) passes above the false ceiling itself, and upon reaching the end of the cold room, begins flowing over the product again.



UNIT COOLER

Tunnel unit cooler range (large capacity)

This range, which is similar to the previous one, enables better performance due also to its greater height (which requires the air intake side to be closed off, both laterally and above, directly within the tunnel freezer).



UNIT COOLER