CAPITAL

Cool Climate Considerations

Contents

Production:
Concept and manuscript: IV Produkt AB, Birger Karlsson
Graphic design: Sörman Information & Media AB
Cover design: IV Produkt AB, David Karlsson
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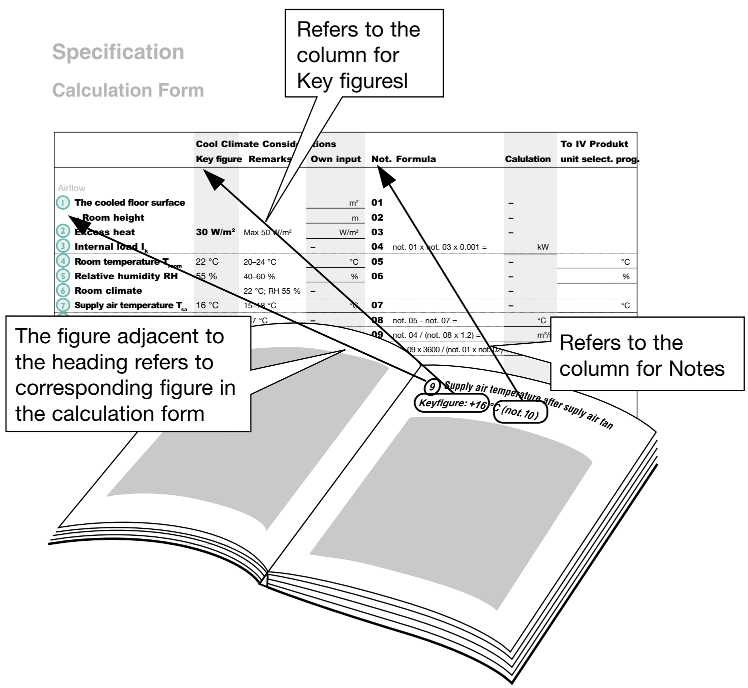
Cool Climate Considerations

”The need for chilled air is on the increase, but this places strict demands on the environment, capacity and energy-efficient solutions. Yet the one demand that we primarily ought to make on the indoor climate inside a building is that the room temperature should be at a comfortable level no matter how the weather is outdoors.

One-piece cooling units designed as direct-acting cooling systems in air handling units make such solutions possible, while the system maintains the right thermal climate and air quality in the premises.

By combining available (free) cooling air intake and cooling energy recovery with a cooling unit switched stage-by-stage, the otherwise necessary total cooling capacity and electric power required can be substantially reduced”.

How to Read the Tables



General

Sizing Procedure

In the ventilation trade, we try to produce the correct climate in premises where people spend time.

Several demands have to be satisfied in order for the occupants to have a sense of well-being. The air in the room has to meet certain requirements. In this handbook, we will be dealing with air comfort issues, such as temperature and humidity.

The purpose of the "Capital C" is to, in a practical and clear way, show how we carry out calculations to determine an optimal choice of cooling unit that will meet our needs for the kind of indoor climate we all expect and deserve.

To determine a ventilation system's total cooling load and airflow requirement, we specify the following two alternative calculations.

Alternative 1, provides us with optimized sizing, where we can analyse and compare alternative suppositions and consider results such as capacity, efficiency, operating costs, pay-off, etc.

In this alternative we can create tenable key figures for future calculations ourselves.

Throughout this handbook, we consistently use air as a heating and cooling agent and we know the nature of the operations conducted in the premises (office, shop, school, computer room, nursing room, etc) as well as the chilled floor area in the premises being conditioned.

Alternative 2, is a sizing method based on an historical approximate calculations using key figures obtained from experience.

Formulas

The following formula for calculating the total cooling capacity of the ventilation system can be used:

$$P_t = q \times \Delta i \times 1.2$$

Total cooling capacity - is the sum of sensible and latent cooling energy. The cooling unit required is sized for obtaining the total cooling capacity.

By sensible, we mean something that can be felt, or coolness that creates a change in temperature measurable with a thermometer.

By latent, we mean hidden coolness which is involved in changing conditions, e.g. when water condenses from the air without changing the air temperature.

To calculate the total airflow of a ventilation system, we use the following formula:

$$q = I_k / (\Delta T \times 1.2)$$

$$P_t = q \times \Delta i \times 1.2$$

P_t = Total cooling cap. in kW
q = Airflow in m^3/s
Δi = $i_{DUT} - i_{KB}$ in kJ/kg dry air.

where:
i_{DUT} = Enthalpy of outdoor air
i_{KB} = Enthalpy downstream of the cooling coil
1.2 = Normal value for air density in kg/m^3

$$q = I_k / (\Delta T \times 1.2)$$

q = Airflow in m^3/s
I_k = Internal cooling load for excess heat in kW
ΔT = $T_{room} - T_{supply\ air}$ in °C

where:
T_{room} = Room temperature
T_{sa} = Supply air temperature
1.2 = Normal value for air density in kg/m^3

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The Mollier Chart

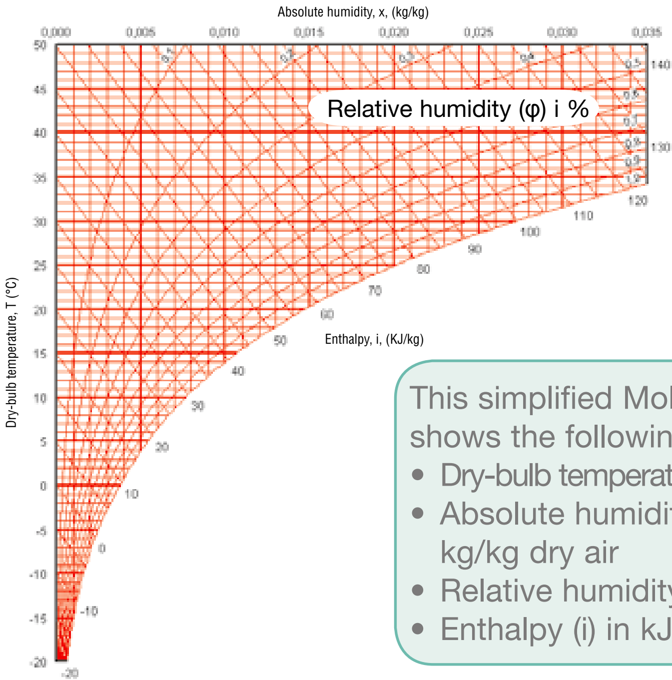
To be able to clearly describe and understand the changes of conditions that occur in the air when we cool or heat it in the following processes, we use a Mollier chart.

The Mollier chart has various scales and curves which illustrate the condition of the air.

For the room conditions that we generally handle within the 0ºC and 30ºC range, the density for the air is between 1.1 - 1.3 kg/m^3. The normal value at 20ºC is 1.2 kg/m^3, which can always be used in practical applications.

> Appendix 1 shows a Mollier chart in larger scale.

Mollier Chart for Moist Air, Barometer Pressure 101.3 kPa



> This simplified Mollier Chart shows the following:
> - Dry-bulb temperature (T) in °C
> - Absolute humidity (x) in kg/kg dry air
> - Relative humidity (φ) in %
> - Enthalpy (i) in kJ/kg air.

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Glossary

Dry-bulb temperature in °C (T) – is the temperature we read on an ordinary thermometer, which is not influenced by evaporation or radiation.

Absolute humidity in kg/kg (x) – is the weight of water vapour per weight unit of dry air.

Example: T = 27 °C
φ = 42 %
x = 0.0093 kg/kg

Relative humidity in % (φ) – to describe how "moist" or how "dry" the air is at a certain temperature, we use the expression relative humidity. Relative humidity is a measurement on how much water vapour the air contains in relation to how much it can contain at same dry temperature.

Example: Dry temp. (T) of 27 °C with a water content (x) of 0.0093 kg/kg has a saturation content (x) of 0.0224 kg/kg.

$$\varphi = \frac{0.0093}{0.0224} = 0.415 \text{ or } 42\ \%$$

Enthalpy in kJ/kg (i) – the heat content of moist air

Example: T = 27 °C and
φ = 42 % has
Enthalpy (i) = 50.9 kJ/kg

Dew point temperature in °C – is the outdoor air temperature at which moisture begins to condense onto the surface. Higher moisture content implies a higher dew point temperature and vice versa.

Example: T = 27 °C and
φ = 42 % has
Dew point temperature = 13 °C

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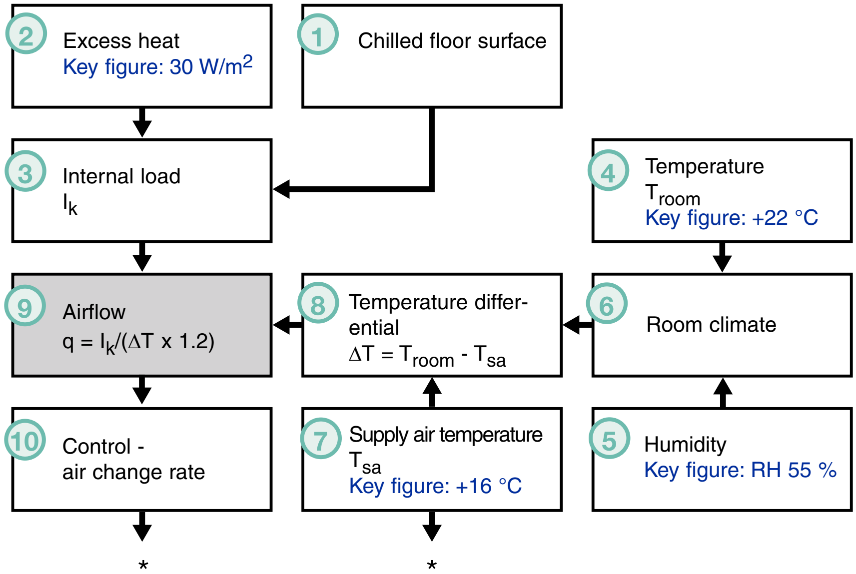
Alternative 1. Optimized Calculation

Airflow



* *See page 14*

1 *Chilled floor surface*

By cooled floor surface we mean the total floor surface served by the air supplied. If we know the total floor surface of the building only, we can, as a rough estimate for schools, offices, day nurseries and similar buildings, then assume that 70 % of the total floor surface is the same as the floor surface to be cooled.

2 *Excess heat*

Key figure: 30 W/m^2 (Not. 03)
A highly advanced computerized calculation program is available for determining the heat load of the premises. This program takes migrating shadows, lag due to accumulation in the building structure, etc. taken into account.

If a quick and practical calculation is needed for a simple building or just one section of a building, figures read from Table 1 on the adjacent page can be used.

Example: A normal office room with an external wall towards the NE and a chilled floor surface of 12 m^2

Heat load (see Table 1)

1.6 m^2	Triple-glazed window with solar protection
1 st	Occupant
120 W	Lighting: Fluorescent tubes
100 W	Computer

Table 1. Approximate cooling load calculation

Objekt		surface-qty-capacity		Coefficient of intensity			Heat load W
				2-pane	3-pane	solar prot.	
Window	NW, N, NE	**1.6**	m^2	330	**300**	**x 0.35**	**168**
Window	E, S		m^2	500	450	x 0.35	
Window	SW		m^2	520	470	x 0.35	
Window	W		m^2	450	400	x 0.35	
External wall			m^2	12			
Roof	False ceiling		m^2	18			
Roof	No false ceiling		m^2	6			
Number of occupants		**1**	st	**115**			**115**
Incandescent lamps			W	1.0			
Fluorescent tubes		**120**	W	**1.2**			**144**
El. machines, computers		**100**	W	**1.0**			**100**
Total heat load in W							**527**

One role of thumb can be that when sharing the heat load, assume that solar protection is available for the windows and that the solar load is not present while lighting is required.

The sum of the excess heat will then be: 527-168 = 359/12 = **30 W/m^2**

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③ *Internal load (I_k)*

The internal load is the heat which should be cooled in the premises, caused by e.g. lighting, occupants, machinery, sunlight, etc.

④ *Temperature (T_{room})*

Key figure: +22 °C (Not. 05)
A measure of perceived thermal comfort is the so called PPD index, which gives the anticipated number of dissatisfied occupants among a larger group of people.

Table 2. Typical demand levels for thermal parameters
Climate Class TQ1 is assumed to provide less than 10 % dissatisfied occupants, whereas Climate Class TQ2 should correspond to 10 % dissatisfied occupants and Climate Class TQ3 20 %.

Indoor climate factor	Factors as per quality class		
	TQ1*	TQ2	TQ3
Operating temperature (to)			
In the winter			
– Highest value °C	23	24	26
– Optimal value °C	22	22	22
– Lowest value °C	21	20	18
In the summer			
– Highest value °C	25.5	26	27
– Optimal value °C	24.5	24.5	24.5
– Lowest value °C	23.5	23	22
Air velocity in the occupied zone			
– Winter conditions m/s	0.15	0.15	0.15 (0.25)
– Summer conditions m/s	0.20	0.25	0.40

* *TQ1 is assessed to be obtainable by means of individual temperature and airflow regulation only.*

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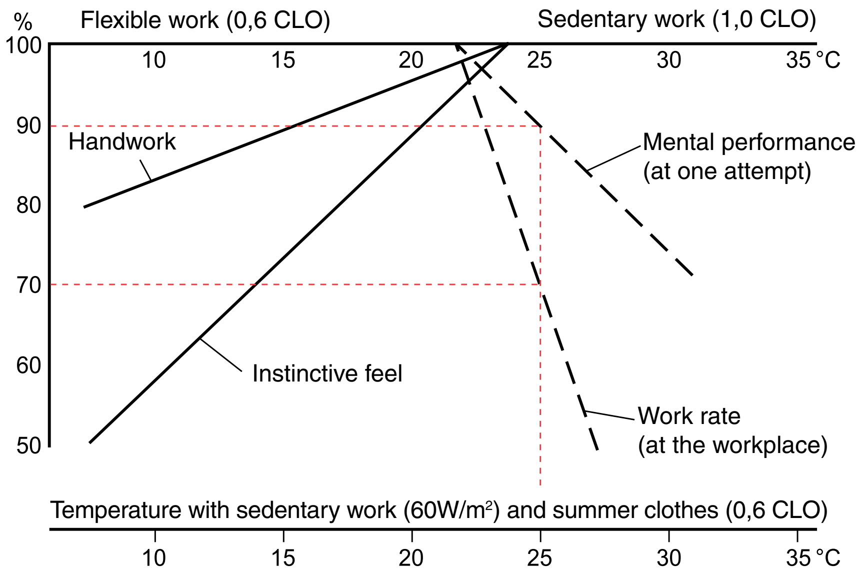
Tests have shown that the room temperature has significant influence on how well humans perform. It is obvious how quickly mental performance and the work rate decreases as the room temperature increases.

Table 3. Indoor climate - productivity



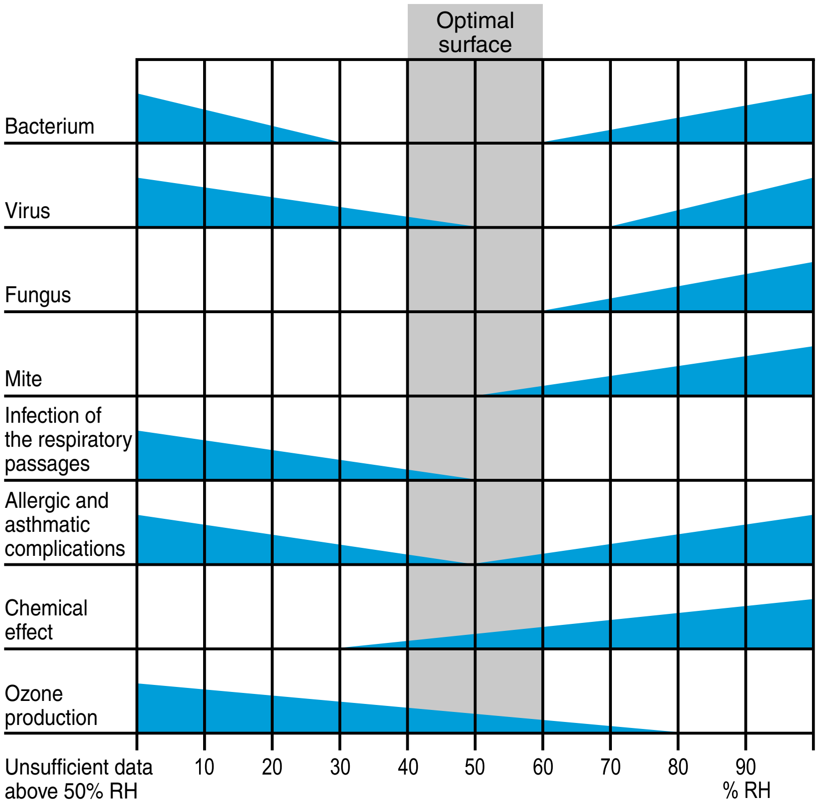
The work pace of a person carrying out ordinary office work in a room where the temperature is +25 ºC, in comparison with a comfort tempera-ture of +22 ºC, will decrease to 70 % and his mental performance will decrease to 90 %. This means that the employer will obtain 70 % of his employees' capacity at the higher temperature.

5 *Humidity*

Key figure: 55 % (Not. 06)

A number of research reports from Sweden, Finland, Germany, etc. dealing with the influence of relative humidity on man, indicate that the negative health hazards for man are minimal if the 40-60 % relative humidity can be maintained indoors.

Table 4 Optimal relative humidity for human health



When we in this construction have not intended to add humidity, it is of great importance that we when cooling of the outdoor air do not remove more humidity than necessary.

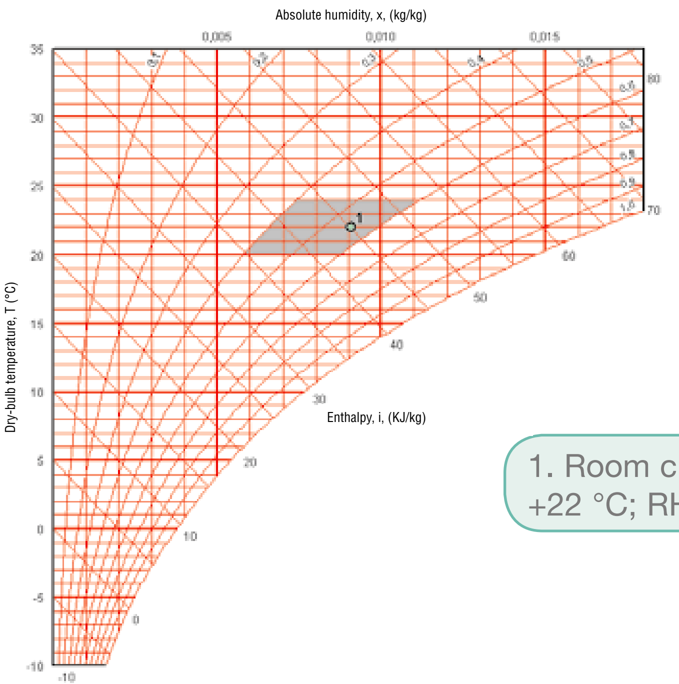
6 Room Climate

(+22 °C; RH 55 %)

People perceive indoor climate in widely different ways, independent of whatever combination of air temperature, humidity, etc. is selected. The limits for what we look upon as sanitary inconvenience are room temperature below +18 °C and above +28 °C in a room environment. However, one should distinguish good comfort, which has a considerably narrower range, normally within the +20ºC to 24ºC interval, which we consider to be a suitable climate range in terms of temperature.

Investigations have shown that the maximal combination only could satisfy 60 % of the persons tested. 20 % thought that it was too hot and 20 % thought that it was too cold. Our selection was +22ºC at 55 % relative humidity, which we have plotted in the Mollier chart

Mollier Chart for Moist Air, Barometer Pressure 101.3 kPa



1. Room climate
+22 °C; RH 55%

7 *Supply Air Temperature downstream of Supply Air Fan (T_{sa})*

Key figure: +16 °C (Not. 07)

In order to dispose of the excess heat in the premises, we have to supply air that has a lower temperature than the room temperature.

Several parameters steer our selection of supply air temperature; these include: the system used for discharging air into the premises, the air device locations selected, etc. Commonly used supply air temperatures are 15 - 18 ºC.

Low supply air temperatures give rise to more dehumidification and less utilization of the outdoor air for free cooling. High supply air temperatures give rise to substantial airflows and high air speeds.

A supply air temperature of + 16 ºC can be said to be a design value. Supplying air having lower temperature can be associated with draught problems. Make sure that the temperature of the air supplied to the premises isn't lower than 7 ºC below the room temperature!

8 *Temperature differential (or temperature below room temp.)*

(max 7 °C)

Temperature differential or temperature below room temperature refers to the difference in degrees Celsius that arises between the temperature in the room and the temperature of the air supplied.

9 *Airflow*

The airflow required is determined by the design internal load and the difference between the temperature in the room and the temperature of the air supplied. It is accordingly the thermal requirements, not the air quality requirements that are decisive for sizing.

10 *Air change rate considerations*

(2.5–8 changes/h)

When we have decided what the air flow rate will be, we check that the air change rate in the premises is acceptable.

The airflow in m^3/h divided by the room volume in m^3 should be between 2.5 and 8 times/hour.

If the number of air changes is less than 2.5, we will have difficulty checking the room temperature. We can then reduce the temperature differential by increasing the temperature of the air discharged into the premises, to increase the airflow and in this manner obtain more air changes as well.

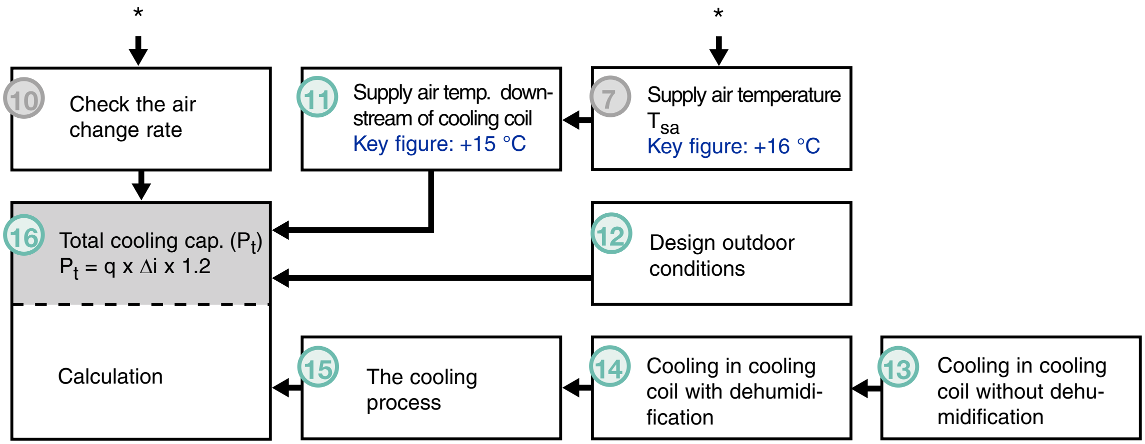
If more than 8 air changes take place each hour, we'll have a difficult time supplying air to the premises without causing draughts and noise. Reduce the airflow by accepting a lower supply air temperature.

N.B!

If the air change rate in the premises exceeds 8 times, while at the same time the supply air temperature is lower than 15 °C, the cooling load in the premises will be greater than what can be cooled by means of air as the cooling medium.

Accept a higher room temperature or select a different cooling system.

Total Cooling Capacity



* *See page 6*

11 *Supply air temperature downstream of cooling coil*

Key figure: +15 °C (Not. 11)

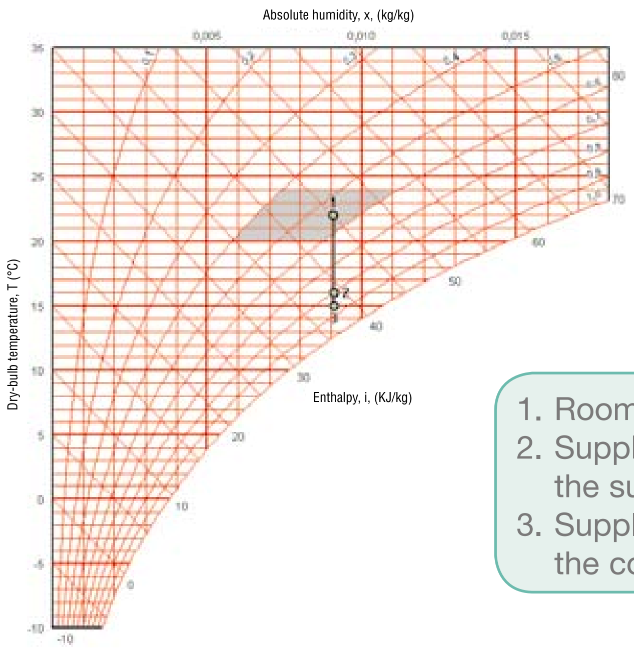
In most ventilation systems, the supply air fan motor is located in the airflow and the supply air absorbs motor heat. The temperature rise involved can be calculated since we already know the motor output; normally we have a temperature rise across the fan motor of approx. 1 °C.

The air temperature downstream of the cooling coil will therefore be 16-1 °C = 15 °C.

We can now plot this process in the Mollier chart. We assume the room climate as being + 22 °C at 55 % relative humidity.

When our air below room temperature is heated in the premises and all heating transpires with constant moisture content, the air temperature downstream of supply air fan and the cooling coil respectively, will accordingly be on the same line, i.e. about 0.009 kg.

Mollier Chart for Moist Air, Barometer Pressure: 101.3 kPa



1. Room climate: +22 °C; RH 55 %
2. Supply air temperature downstream of the supply air fan: +16 °C
3. Supply air temperature downstream of the cooling coil: +15 °C

The line plotted in the chart indicates the supply air temperature to which the outdoor air should be cooled, i.e. +15 °C.

Exactly where this point will be in the real process is determined by:

- Design outdoor conditions, as well as
- The evaporation temperature preset on the cooling unit.

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⑫ *Design Outdoor Air Conditions*

The Summer DOC for various locations

The design air temperature and relative humidity that we will use in the summertime to cool the air can be obtained from statistics made by the Sweden Meteorological and Hydrological Institute, SMHI. The excerpts below from these data show the highest figures recorded at a specific location. The statistics are based on the assumption that the values are exceeded max. 50 hours/year.

(These are the swedish design data. Please use your local data for correct design.)

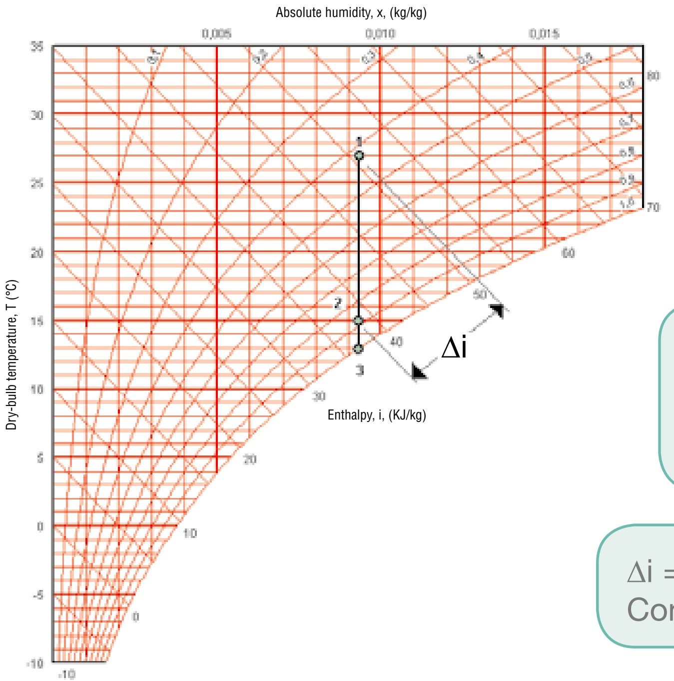
Example
The design values for Växjö are:
Temperature = 27 °C
Relative humidity = 42 %

LOCATION	DOC 50 °C	Relative humidity %
Borlänge	28	36
Linköping	27	42
Växjö	27	42
Örebro	27	42
Malmö	26	48
Halmstad	26	47
Stockholm	26	45
Sundsvall	26	41
Gävle	26	39
Jönköping	25	51
Kalmar	25	48
Östersund	25	46
Luleå	25	46
Umeå	24	48

⑬ *Cooling in Cooling Coil without Dehumidification*

When air is being cooled, the sequence is contingent on the surface temperature of the coil. If the evaporation temperature of the incoming refrigerant is higher than the dew point of the incoming air, no condensate precipitation will occur and this provides so called “dry cooling”. Air cooling in this case occurs according to a vertical line plotted in the Mollier Chart with a constant humidity content (x).

Mollier Chart for Moist Air, Barometer Pressure: 101.3 kPa



Δi = Sensible

1. Outdoor climate: +27 °C, RH 42 %
2. Supply air temperature downstream of cooling coil: +15 °C
3. Evaporation temperature: +13 °C

Δi = 50.9 - 38.1 = 12.8 kJ/kg luft
Condensate precipitation: x = 0 kg/kg air

This is the optimal cooling process we want to imitate. Accordingly, cooling without condensate precipitation means pure sensible cooling.

14 *Cooling in cooling coil with dehumidification, evaporation 12ºC*

If the evaporation temperature is lower than the dew point of the air the course will be more complicated.

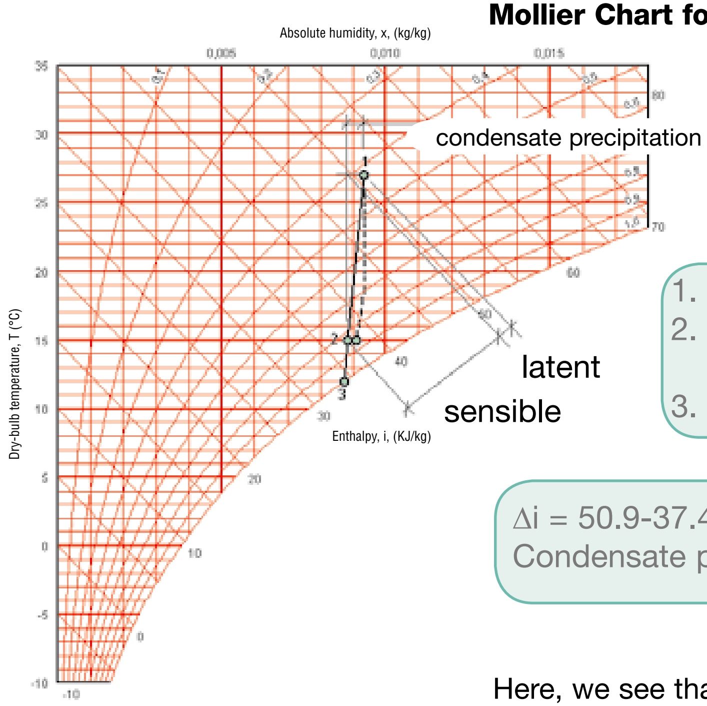
In a direct-acting cooling system the temperature of the refrigerant is constant through the whole coil. The rate of condensate precipitation in such a system will therefore be greater, the lower the evaporation temperature is. And here, we say that, besides sensible cooling, we also obtain latent cooling.

The process in the Mollier chart itself cannot be described in its entire phase change, since it follows a curved line from the starting condition of the air to the desired air discharge temperature. The reason for this

is that the temperature on the cooling surfaces is not constant throughout the cooling coil, but most often is higher across the first tube rows than further in. Even if the temperature of the refrigerant is constant, a larger flow of heat in the part of the cooling coil where the air is the hottest, will cause the surface temperature to be higher than further in where the air is colder.

We will therefore carry out our calculations according to the theoretical process, where we follow the straight line from the condition of the outdoor air towards the evaporation temperature on the saturation line.
The calculation method however gives us a somewhat higher cooling capacity than needed.

Mollier Chart for Moist Air, Barometer Preasure: 101.3 kPa



Δi = Sensible + latent

1. Outdoor climate: +27 °C, RH 42 %
2. Supply air temperature downstream of the cooling coil: +15 °C
3. Evaporation temperature: +12 °C

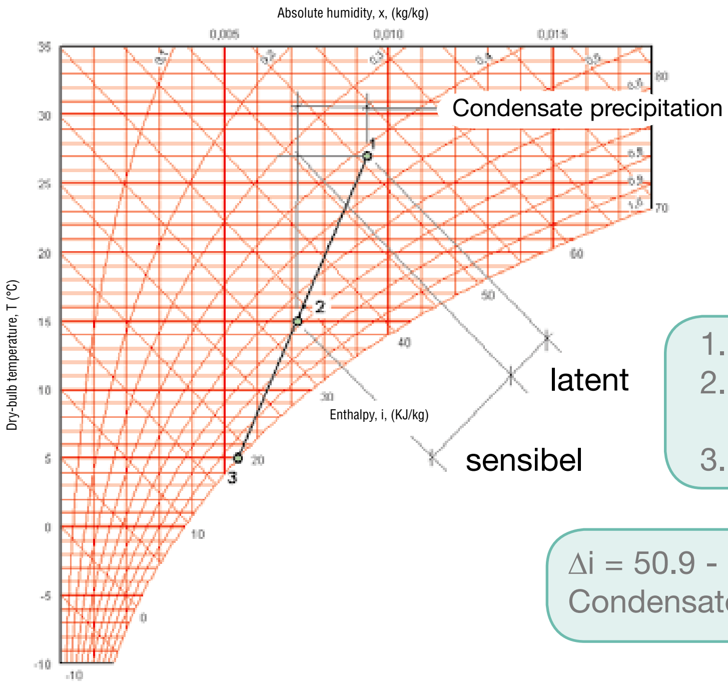
Δi = 50.9-37.4 = 13.5 kJ/kg luft
Condensate precipitation: x = 0.0005 kg/kg air

Here, we see that by lowering the evaporation temperature from 13 to 12 °C, the total cooling demand increases by (13.5 - 12.8)/12.8 = 5.5 %.

Cooling in Cooling Coil with Dehumidification, Evaporation 5ºC

Cooling units with an evaporation temperature of +5ºC is traditionally common. Let us therefore study also this process in the Mollier chart.

Mollier Chart for Moist Air, Barometer Pressure: 101.3 kPa



Δi = Sensible + latent

1. Outdoor climate: +27 °C, RH 42 %
2. Supply air temperature downstream of the cooling coil: +15 °C
3. Evaporation temperature: +5 °C

Δi = 50.9 - 33.2 = 17.7 kJ/kg air
Condensate precipitation: x = 0.0021 kg/kg air

For the same design temperature reduction as for cooling by means of a cooling coil without dehumidification, we obtain a cooling unit offering approx. 40% higher cooling capacity.

A larger than necessary cooling unit will have to frequently start and stop making it difficult to regulate the air temperature and the unit's brief operating periods will jeopardize its reliability in operation.

Economical and correct technical sizing gives us an evaporation temperature that is 3 - 5 ºC lower than the air temperature downstream of the cooling coil.

15 *The Cooling Process*

To obtain the correct mixture of cooling energy and humidity, the following demands should be made on the cooling equipment:

- It must be able to lower the air temperature without giving rise to condensate.This can be achieved by sizing equipment for a high rate of evaporation.

The selection of evaporation temperature is decisive for how large the total cooling capacity will be. A high evaporation temperature provides the following results:

- low total cooling capacity
- low connected amperage for electric power
- low power consumption

16 *Total Cooling Capacity (P_t)*

Knowing the total cooling load and the airflow, we can now calculate the total cooling capacity required.

- The total cooling load is obtained as a difference between the enthalpy of the outdoor air and the enthalpy of the cooled air downstream of the cooling coil.

Specification

Calculation Form

	Cool Climate Considerations Key figure	Remarks	Own input	Not.	Formula	Calculation	To IV Produkt unit.select. prog.
Airflow							
1 **The cooled floor surface**			**560** m^2	**01**		–	
– **Room ceiling height**			**2.4** m	**02**		–	
2 **Excess heat**	**30 W/m^2**	Max 50 W/m^2	**30** W/m^2	**03**		–	
3 **Internal load I_k**			–	**04**	not. 01 x not. 03 x 0.001 =	**16.8** kW	
4 **Room temperature T_{room}**	**22 °C**	20–24 °C	**22** °C	**05**		–	**22.0** °C
5 **Relative humidity RH**	**55 %**	40–60 %	**55** %	**06**		–	**55.0** %
6 **Room climate**		22 °C; RH 55 %	–			–	
7 **Supply air temperature T_{sa}**	**16 °C**	15–18 °C	**16** °C	**07**		–	**16.0** °C
8 **Temperature differential ΔT**		5–7 °C	–	**08**	not. 05 - not. 07 =	**6** °C	
9 **Airflow q**			–	**09**	not. 04 / (not. 08 x 1,2) =	**2.33** m^3/s	**2.33** m^3/s
10 **Control of air changes**		2.5–8 changes/h	–	**10**	not. 09 x 3600 / (not. 01 x not. 02) =	**6.25** changes/h	
Cooling capacity							
11 **Supply air after cooling coil**			–			–	
– **Temperature**	**15 °C**		**15** °C	**11**		–	
– **Enthalpy**		To Mollier chart	**37.4** kJ/kg	**12**		–	
12 **Design outdoor air conditions**			–			–	
– **District**		Acc. to SMHI	**Växjö**	**13**		–	
– **Temperature**		Acc. to SMHI	**27** °C	**14**		–	**27** °C
– **Relative humidity**		Acc. to SMHI	**42** %	**15**		–	**42.0** %
– **Enthalpy Δi**		To Mollier chart	**50.9** kJ/kg	**16**		–	
16 **Total cooling capacity P_t**			–	**17**	not. 09 x (not. 16 - not. 12) x 1.2 =	**37.8** kW	

Air handling with the focus on LCC

Cost Analysis

Over the years, the installation and operation of a cooling system has been considered too costly and consequently this has been regarded as an unnecessary luxury!
By presenting a few examples, we shall try to clarify whether this is the case and, if so, why.

Pay-off

Could it be possible that an installation of cooled air could be profitable? Let us see!

With today's increasing indoor heat loads from computers, printers, copiers, etc, it is not unlikely that the temperature indoors is or exceeds 25°C for more than 200 hours/year.

Looking back at previous analyses of the room temperature, it can be established that the working pace of an employee decreases to 70 % at a room temperature of 25°C.

If we per employee count on a cost per hour of 200 SEK including expenses, the loss will be 0.3 x 200 x 200 = 12 000 SEK/employee and year!

If each employee disposes a surface of 20 m2, which means that an investment of 600 SEK/m^2 for cooled air has paid off already in one year.

In our example specified on the calculation form, we have premises with a cooled floor surface of 560 m^2. In accordance with the above key figure we can therefore have 560 x 600 SEK = 336 000 SEK/year at our disposal for the installation of a cooling system!

Operating Costs

Let’s now study what it can cost to operate our cooling system.

We assume that the airflows for cooling and for heating in out ventilation unit are the same and therefore focus our attention on the additional cost for cooling.

At the same time, we are comparing both alternatives described with various evaporation temperatures.

Our Alternative for + 12ºC Evaporation

Prerequisites

		Supply air
Airflow		2.33 m³/s
Temperatures	Cooling cond.	16 °C
Mean annual temperature		6.4 °C
Type of operation		Dagtid 09 - 21
In-operation time		4380 h
Energy price		0.6 kr/kWh
Evaporation temperature		12 °C

According to our calculation a total cooling capacity of 37.8 kW is required under these conditions and we assume efficiency across the compressor (COP) of 3.8 and a supply air fan having a motor output equivalent to 3.0 kW.

Results

Duration		**Cooling**
Annual cooling energy		7356 kJh/kg air
Energy distribution		
Total requirement		20568 kWh
Latent cooling energy (dehumidification of air)		1413 kWh
Energy for operating the unit		
Compressors	Total	5413 kWh
Operating cost		
Cooling energy	Total	3248 kr/year
Capacities required		
Electricity for cooling operation		9.9 kW (nto)

The Alternative with +5ºC Evaporation

Prerequisites

		Supply air
Airflow		2.33 m^3/s
Temperatures	Cooling cond.	16 °C
Mean annual temperature		6.4 °C
Type of operation		Daytime 09 - 21
In-operation time		4380 h
Energy price		0.6 kr/kWh
Evaporation temperature		5 °C

According to the example plotted in the Mollier Chart, a total cooling capacity of 2.33 x 17.7 x 1.2 = 49.5 kW is required here.
At the same time, we obtain, due to the lower evaporation temperature, decreased efficiency, COP = 3.1 while we maintain the supply air fan's motor output of 3.0 kW.

Results

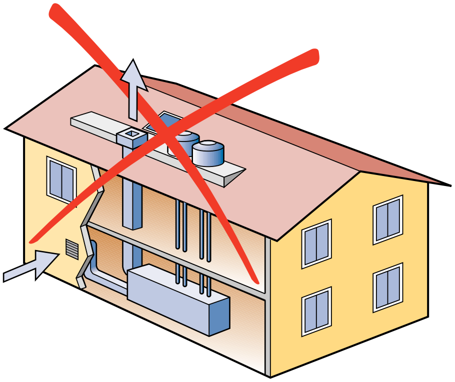
Duration		Cooling
Annual cooling energy		8078 kJh/kg air
Energy distribution		
Total requirement		22587 kWh
Latent cooling energy (dehumidification of air)		3432 kWh
Energy for operating the unit		
Compressors	Total	7286 kWh
Operating cost		
Cooling energy	Total	4372 kr/year
Capacities required		
Electricity for cooling operation		16.0 kW (nto)

Conclusion
We can see here that the annual cost for operating the cooling unit is infinitesimally small and that it together with the installation cost shouldn't be a motive for not installing chilled air.

Comparing the examples, we can also see that it is economical to size the contemplated ventilation system for cooling air having a high evaporation temperature.

IV PRODUKT
Air handling with the focus on LCC

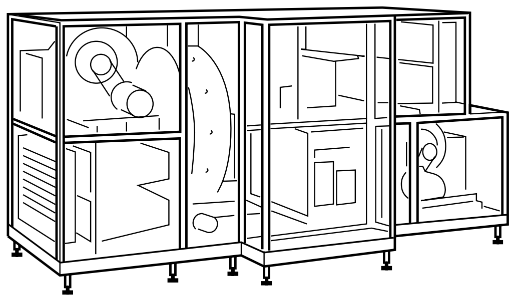
Selecting the Cooling Unit

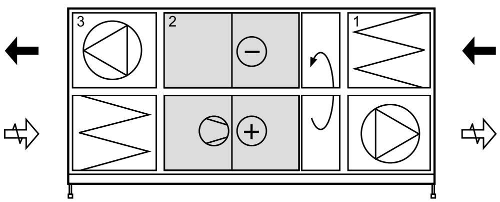


"Cooling, air handling and ventilation can no longer be dealt with as separate functions isolated from one another."

The new systems incorporating the StarCooler direct-acting one-piece cooling unit models are designed to satisfy the expectations of the designer, the fitter as well as the end user.

These integrated systems spare the end users discomfort caused by noisy and, in many cases, esthetically disturbing installations on the roof of the building or on the ground.
All items of equipment are in the fan room.





The StarCooler is assembled as a complete ready-to-use functional section for incorporation into an air handling unit.

The evaporator, compressor and condenser are installed directly in the supply air and extract air of the air handling unit respectively.

Air handling with the focus on LCC

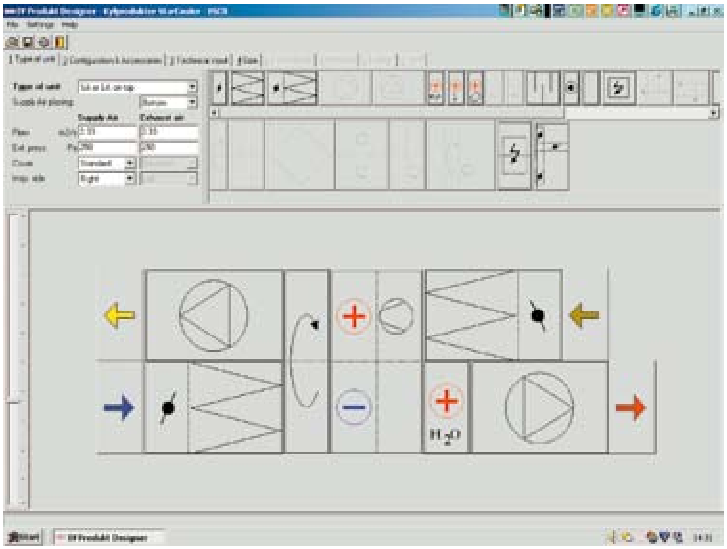
The IV Produkt computerized unit selection program makes selecting the right system easy, simplifies sizing and includes a means for exporting your sizing results to a CAD file.

Select the Envistar with the StarCooler, the complete air handling unit with complete controls or construct your own unit of Flexomix functional sections.

Flexomix components enable you to incorporate our new StarCooler Plus unit for optimum cooling capacity and minimal power consumption.

Do you have heating or power problems, select our Enviquattro air-conditioning unit.

Envistar with the ESCR StarCooler



Here you can select a rotary heat exchanger or an optional plate heat exchanger in combination with the StarCooler cooling unit.

The unit is available for airflows from 0.4 till 3.3 m^3/s and with cooling capacity from 9 to 40 kW.

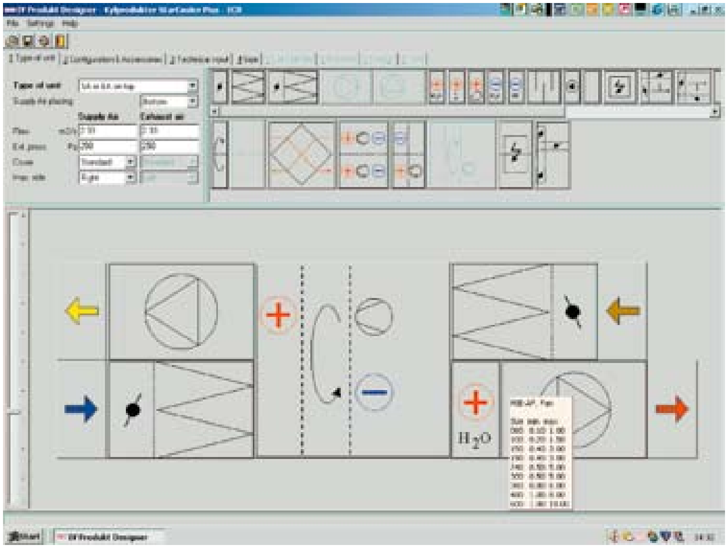
These cooling capacities make it possible to chill the supply air from 27 to 16 °C, at a nominal airflow, with an evaporation temperature of +10 °C and with a coefficient of cooling performance (COP) of 3.8.
Cooling is obtained in 3 steps (2 steps in the size 09 units) by means of a built-in stepping switch.

The size 18 and smaller StarCooler units each contain less than 3 kg of refrigerant per circuit.

This means that no report need be submitted to authorities and that the system is exempt from annual inspection by authorities.

Air handling with the focus on LCC

The Flexomix with the ECR StarCooler Plus



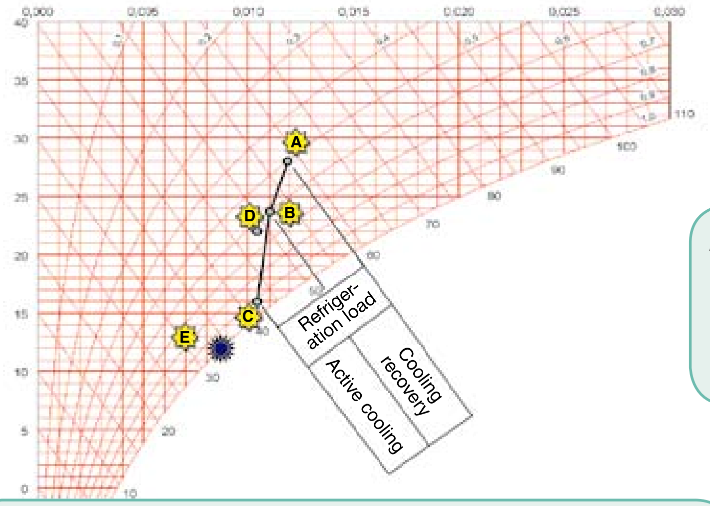
Selecting the StarCooler Plus provides you with a cooling unit that can operate in combination with a rotary heat exchanger. The heat exchanger operates in sequence with the cooling unit.

A hygroscopic heat exchanger, besides providing temperature transfer, also transfers humidity from the extract air.

The StarCooler Plus is available in two variants for airflows from 1.0 to 6.0 m³/s and cooling capacity from 25 to 135 kW.

With this process and this range of cooling efficiencies, your system will be able to tackle the most commonly occurring cooling loads in northern Europe and with an evaporation temperature of +12 °C and a COP equal to 5.8. Cooling is obtainable in 4 stages switched in by an integrated stepping switch.

Example: An Application incorporating the StarCooler



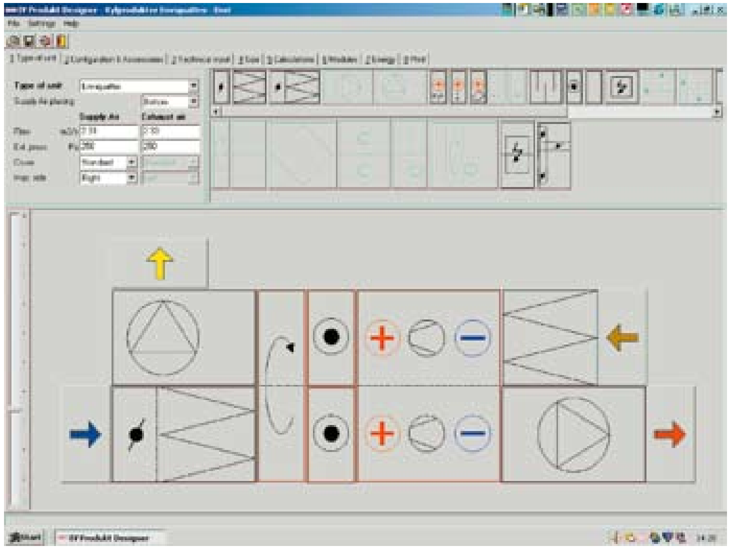
A Outdoor air
B New cooling point
C Supply air temperature desired
D Room temperature
E Evaporationtemperature

Direct-acting cooling system, with a high rate of evaporation and stage-by-stage switched cooling performance offers high efficiency.

The cooling unit and heat exchanger rotor share the cooling load.

Low rated amperage
Shorter in-operation times
Lower energy consumption

Enviquattro

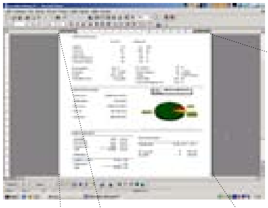


The Enviquattro is the complete climate unit. In the wintertime, the cooling unit can be used as a heat pump in sequence with the rotary heat exchanger.

The Enviquattro is available for airflows from 1.1 to 6.0 m³/s and has cooling capacity ranging from 26 to 115 kW.

Cools in the summertime, heats without the need for extra heating in the wintertime. In this way, the unit can operate on power supplied with extremely low amperage.

Energy Declaration for a given Heating Conditions



Enviquattro
Energy Calculation

Project	Kylprodukter	Page	1
Type of unit	Enviquattro	Date	2002-12-10
Size	300-2	Time	08:53:32
		Signature	birk

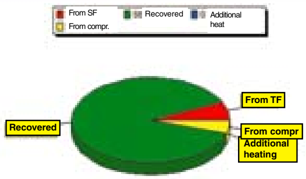
PREREQUISITES

	SUPPLY AIR	EXTRACT AIR	
Air flow	2,3	2,3	m3/s
Total pressure	621	684	Pa
Temperature	19	22	°C
Fan efficiency	68	68	%
Total fan efficiency	54	55	%

Annual mean temp.	6,4	°C	Design outd. temp.	-20	°C
Energy price	0,55	SEK/kWh	Add. heat price	0,55	SEK/kWh
Operating time	3 200	hrs/year	Type of operation	D	Daytime/24 hr period
Heat exchanger	Enviquattro		Heating capacity	57,5	kW
			Temp. efficiency, heat exch.	75,6	%

ENERGY RECOVERY

Total load	105446 kWh (100%)
Additional heat	0 kWh (0%)
Recovered	92425 kWh (88%)
From supply air fan	7137 kWh (7%)
From compressor	5884 kWh (5%)



ENERGY FOR OPERATION

Supply air fan	8 635	kWh/year
Extract air fan	9 917	kWh/year
Compressors	5 884	kWh/year
Total	24 436	kWh/year

Operating cost

El. fans and compressors	13 439	SEK/year
Addtional heating	0	SEK/year
Total	13 439	SEK/year

Capacities required

Additional heat	0 kW (18 C -> 18 C)	
El. for heating	15	kW (nto)
El. for cooling	21	kW (nto)

Additional heat: 0 kW

Temperature upstream of supply air fan

Total connected power cooling unit + fans

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Alternative 2.
Historical Approximate Calculation

We've been sizing airflow and cooling capacity needs for a long period of time. We were often satisfied with performing simple approximate calculations, by means of figures obtained by experience (key figures), for determining the airflow and cooling capacity needs of a building.

The use of key figures gave us opportunity to determine the airflow rate and the size of ventilation unit with cooling coil. This also enabled us to procure the information needed to size a cooling unit.

On the other hand, we couldn't understand what result in terms of supply air temperature, internal load capacity, COP, connected power, etc. our assumption gave us.

Commonly occurring key figures were obtained by multiplying the chilled floor area in the premises with:

The airflow of the unit	12-15 m^3/h
The cooling unit's total cooling capacity	80-85 W

According to our "optimized calculation example" with a chilled floor area of 560 m^2, we obtained an airflow rate of 2.33 m^3/s and a total cooling capacity of 37.8 kW.

We will now see if the “historical approximate calculation” can also apply today. Let’s calculate an airflow of15 m^3/h and a cooling capacity of 85 W.

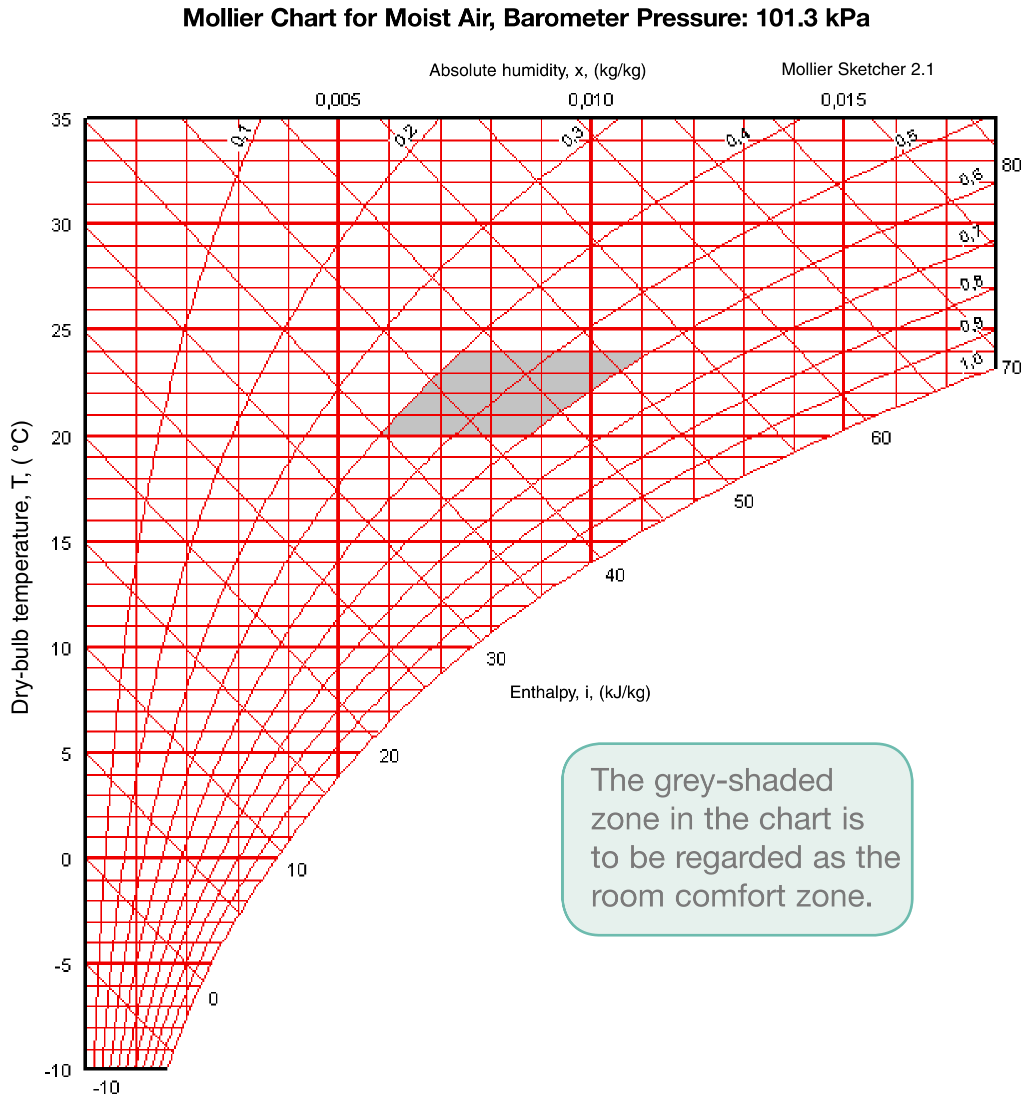
The airflow rate will then be; 560 x 15 = 8400 m3/h or 2.33 m^3/s
and the total cooling capacity of the cooling unit: 560 x 85 = 47600 W or 47.6 kW.

As we can see, we would have found out the airflow rate if we had selected 15 m^3/m^2 as a key figure.

As far as the cooling capacity is concerned, we would have had an excessively large cooling unit, which can be explained by the fact that yesterday’s key figures were based on the cooling unit having had an evaporation temperature of +5ºC instead of +10 to 12 ºC obtained in our optimized calculation.

From this we can see that the key figures can be used for quick approximate calculations, but are not adequate enough for ultimate sizing.

Appendix 1. Mollier Chart



The grey-shaded zone in the chart is to be regarded as the room comfort zone.

Appendix 2. Calculation Form

		Cool Climate Considerations Key figure	Remarks	Own input	Not.	Formula	Calulation	To IV Produkt unit select. prog.
	Airflow							
1	**The cooled floor surface**			m^2	**01**		–	
	– Room height			m	**02**		–	
2	**Excess heat**	**30 W/m²**	Max 50 W/m²	W/m²	**03**		–	
3	**Internal load I_k**			–	**04**	not. 01 x not. 03 x 0.001 =	kW	
4	**Room temperature T_{room}**	**22 °C**	20–24 °C	°C	**05**		–	°C
5	**Relative humidity RH**	**55 %**	40–60 %	%	**06**		–	%
6	**Room climate**		22 °C; RH 55 %	–			–	
7	**Supply air temperature T_{sa}**	**16 °C**	15–18 °C	°C	**07**		–	°C
8	**Temperature differential ΔT**		5–7 °C	–	**08**	not. 05 - not. 07 =	°C	
9	**Airflow q**			–	**09**	not. 04 / (not. 08 x 1.2) =	m³/s	m³/s
10	**Control of air changes**		2.5–8 changes/h	–	**10**	not. 09 x 3600 / (not. 01 x not. 02) =	changes/h	
	Cooling capacity							
11	**Supply air after cooling coil**			–			–	
	– Temperature	**15 °C**		°C	**11**		–	
	– Enthalpy		To Mollier chart	kJ/kg	**12**		–	
12	**Design outdoor conditions**			–			–	
	– District		Acc. to SMHI		**13**		–	
	– Temperature		Acc. to SMHI	°C	**14**		–	°C
	– Relative humidity		Acc. to SMHI	%	**15**		–	%
	– Enthalpy Δi		to Mollier chart	kJ/kg	**16**		–	
16	**Total cooling capacity P_t**			–	**17**	not. 09 x (not. 16 - not. 12) x 1.2 =	kW	

SMHI: The the Swedish Meteorological and Hydrological Institute

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List of References

VVS 2000, Tabeller och Diagram *(Tables and charts)*
SMHI *(Swedish Meteorological and Hydrological Institute)*
Luftbehandling 2 *(Air Handling)*, Gunnar Lilja, Liber förlag
Termisk komfort *(Thermal Comfort)*, Leif Davidsson, Ahlsell kyl
Klimatteknologi *(Climate Technology)*, Torkel Andersson, DELTAte
RAPPORT EFFEKTIV 200:1, Per-Erik Nilsson

"The need for chilled air is on the increase, but this places strict demands on the environment, capacity and energy-efficient solutions. Yet the one demand that we primarily ought to make on the indoor climate inside a building is that the room temperature be at a comfortable level no matter how the weather is outdoors. One-piece cooling units designed as direct-acting cooling systems in air handling units make such solutions possible, while the system maintains the right thermal climate and air quality in the premises. By combining available (free) cooling air intake and cooling energy recovery with a cooling unit switched stage-by-stage, the otherwise necessary total cooling capacity and electric power required can be substantially reduced."

IV PRODUKT

Air handling with the focus on LCC

IV Produkt AB, Box 3103, SE-350 43 VÄXJÖ, Sweden
Phone: +46 470-75 88 00 • Fax: +46 470-75 88 76
E-mail: info@ivprodukt.se • Web: www.ivprodukt.se

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