Humid air accuracy

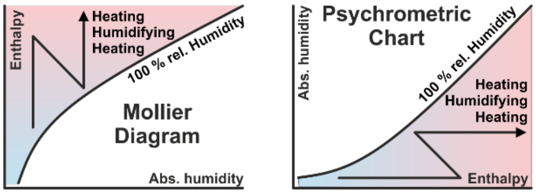
There is free software, although you often have to realize, that if something costs nothing, it is not worth much. There is software, that costs only half as much, although it has to be said, that it may only offer half the possibilities. There is our software, which is currently used by more than 8,200 engineers worldwide.

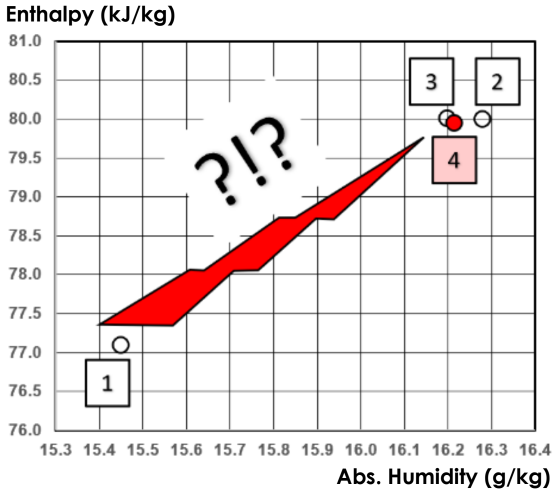
Under www.unilab.eu you can read: ***We have been providing high-quality heat transfer software for over 30 years. We are the only software company with an in-house department for thermal engineering.*** But I have been developing neutral software for the same market since 1987 and have been dealing exclusively with thermodynamics for fin coil heat exchangers since 1970. That's why the ***quality of Unilab software*** made me suspicious. Various online calculators for the Mollier-HX-Diagram showed considerable deviations at an air pressure of 1,013 bar, a temperature of 38°C and a relative humidity of 39%.

1. www.unilab.eu
2. www.i-r-b.de
3. www.hassler-kaeltetechnik.de
4. www.zcs.ch

In reference books, you can find the specific temperature-related heat capacity. This value shows, how much energy has to be used, to heat the medium by 1°C at the appropriate temperature. If you wants to know, what energy is required, to heat the medium from t1 to t2 or from 0 to t, then the mean of the specific temperature-related heat capacity must be determined.

AHH (Air Humid Handling) = All in one!





$$cp = \frac{\int_{t_1}^{t_2} cp_t dt}{t_2 - t_1} \rightarrow cp = \frac{\int_0^t cp_t dt}{t}$$

If the Mollier-HX-Diagram already shows deviations of 1 g/kg absolute humidity, the question arises, as to the accuracy of the calculation of fin coil heat exchangers...

As early as 1967 at the Technical University in Winterthur, it was pointed out in vain, that in processes with gases, only the dry mass flow in kg/h remains constant. Nevertheless, in tenders in air conditioning technology, the humid volume flow in m3/h is always put out to tender, of course **without reference to the plant height above sea level and without reference to temperature and relative humidity**.

This is the ideal bullshit basis for **deviations of up to 40%** in offers for fin coil heat exchangers, although it is pointed out in vain, that **a temperature of 20°C and a relative humidity of 40% should be set as base values**.

I have pointed this out in vain, to corresponding associations, such as the SWKI in Switzerland, the VDI in Germany and hundreds of planning engineers without any success. Now it's the year 2025, 58 years later, and I have to say with total disillusionment, that nothing has changed at all in this regard.

As an example, let's take an air volume of 10,000 m3/h at 20°C/40% at sea level, where the air is to be heated from -16°C/100% to 24°C/5,1%. This corresponds to a dry air mass flow of 11,927,8 kg/h and an output of 133,6 kW.

With the **AHH** (Mollier-HX-Diagram) software, the air flow rate of 10,000 m3/h was determined first at the inlet and then at the outlet, resulting in an **unacceptable deviation of 16%** in terms of performance. If the plant in Zermatt is located at an altitude of 1,600 meters above sea level, this results in an output of only 109,5 kW and an **unacceptable deviation of 40%!**

Correct physical constants for air and water play an important role in the calculation of processes with humid air and therefore also in the Mollier-HX-Diagram. I use internationally confirmed values for this.

Universal gas constant	J/kMolK	8,314.463
Heat of evaporation of water at 0.01°C	J/kg	2'500'500.000
Molecular weight of water	kg/kMol	18.015
Molecular weight of air	kg/kMol	28.949

This led to a customer's question: Why is it listed in the DEH software, the cost-effectiveness of air conditioning units with energy recovery, that an **energy expenditure of 69.458 MWh is required for 100 tons of humidification**, regardless of whether you humidify with water or steam?

Heat of evaporation of water at 0.01°C	J/kg	2,500,500.000
Evaporation quantity	t	100.000
Evaporation quantity	kg	100,000.000
Energy requirement (2,500,500x100,000/3,600)	Wh	69,458,333.333
Energy requirement	kWh	69,458.333
Energy demand	**MWh**	**69.458**

Key value in the Mollier HX diagram

$$C = \frac{Q}{\Delta tm} = kA$$

Under Options/Airflow Inlet, select the unit m3/h relative to 20°C/40%. You get the amount of air in kg/h, which remains constant through all processes.

Process 1: Definition of the air volume = 30,000 m3/h

Under Options/Airflow Input, select the unit kg/h and use it to calculate all subsequent processes.

Process 2: Heat recovery in winter
Process 3: Supply air re-heating in winter
Process 4: Supply air humidification in winter
Process 5: Exhaust air humidification in summer
Process 6: Cold recovery in summer
Process 7: Supply air re-cooling in summer
Process 8: Supply air reheating in summer

In the processes for heating and cooling air, the temperatures for the liquid medium, such as water or brines, must be entered. From these values, the mean logarithmic temperature difference is calculated. If you divide the power by the mean logarithmic temperature difference, you get a key value.

For the k-value, values between 0.03 and 0.06 kW/m2K apply, whereby these depend primarily on the permissible pressure losses. Now we know what surface area is needed for the heat exchangers. If you also know the specific costs from experience, you can estimate how much these heat exchangers are likely to cost.

Example of the heater (3)

Power Q = 275,389 kW
Mean log. Temp. diff. Δtm = 24.355 K
Key value C = 275,389 / 24,355 = 11,307 kW/K
k-value = 30 W/m2K = 0.03 kW/m2K
Heating area A = 11,307 / 0.03 = 376,910 m2
Specific costs S = 10 CHF/m2
Heater price = 10 x 376,910 = CHF 3,769

Example of a cooler (7)

Power Q = 303,500 kW
Mean log. Temp. diff. Δtm = 8.406 K
Key value C = 303,500 / 8,406 = 36,103 kW/K
k-value = 60 W/m2K = 0.06 kW/m2K
Radiator area A = 36,103 / 0.06 = 601,753 m2
Specific costs S = 10 CHF/m2
Radiator price = 10 x 601.753 = CHF 6'018

Example of a heat recovery system (2)

Power Q = 203,784 kW
Mean log. Temp. diff. Δtm = 11.178 K
Key value C = 203,784 / 11,178 = 18,231 kW/K

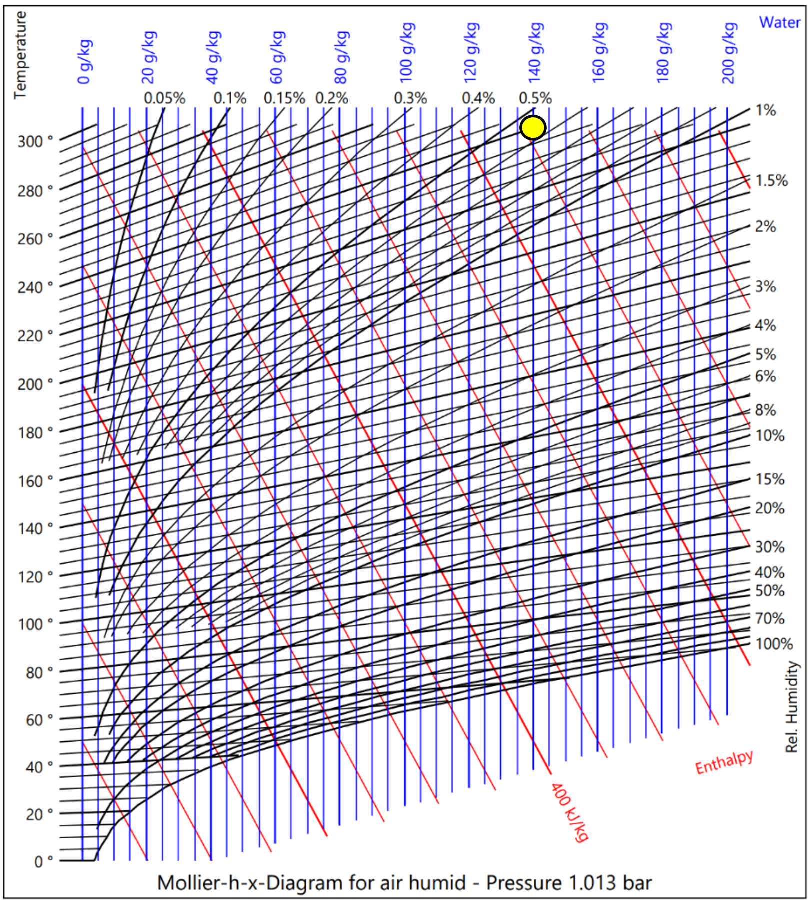
2 heat exchangers in the heat rec. system
Key value C = 2 x 18,231 = 36,462 kW/K

Pro heat exchanger in the heat rec. system
k-value = 30 W/m2K = 0.03 kW/m2K
WT area A = 36,462 / 0.03 = 1215,400 m2
Specific costs S = 10 CHF/m2
WT price = 10 x 1215,400 = CHF 12,154
2 heat exchangers total CHF 24,308

The **Mollier HX diagram** is particularly suitable in a temperature and humidity range where the temperature lines rise only moderately and are therefore not perceived as disturbing.

Supported Area
Pressure from 0.03 to 16 bar
Temperature from -100 to 300°C
Moisture from 0 to 1000 g/kg

Yellow dot
240°C/140 g/kg.



Less than 80 process engineers, 100 times fewer engineers than in the HVACR industry, prefer my **Excel-developed Mollier TX diagram**, where all temperature lines run horizontally. For this purpose, the enthalpy lines become enthalpy curves.

Supported Area
Pressure from 0.03 to 16 bar
Temperature from -100 to 500°C
Humidity from 0 to 3000 g/kg

Yellow dot
240°C/140 g/kg