

EXAMPLES: Wet scrubber

Unsaturated air entering a wet scrubber has: t_1 (dbt_{emp}) = 20°C; RH, relative humidity = 50% (v/v). Calculate: h_1 , h_2 (sat.), t_{wetbulb} , x_1 , and x_2 .

ANSWERS:

$$h_1 = 1.005 \cdot t_1 + x_1(1.84 t_1 + 2501)$$

$$t_1 = 20^\circ\text{C}$$

$$x_1 = m_{\text{H}_2\text{O}} / m_{\text{dry air}} = 18 \cdot p_{\text{H}_2\text{O}} / 29 \cdot (p - p_{\text{H}_2\text{O}})$$

Where:

- $p_{\text{H}_2\text{O}}$ = partial pressure of water vapor
- p = total gas pressure = 1 atm = 98070 Pa

The partial pressure of water vapour can be estimated by the information of $RH = 100 \cdot (p_{\text{H}_2\text{O}} / p_{v,\text{H}_2\text{O}})$

The $p_{v,\text{H}_2\text{O}}$ at 20°C is tabulated and equal to 2265 Pa (see next slide), therefore $p_{\text{H}_2\text{O}}$ is equal to 1132 Pa.

$$x_1 = (18 \cdot 1132) / (29 \cdot (98070 - 1132))$$

$$x_1 = 0,0073 \text{ kg}_{\text{water vapor}} / \text{kg}_{\text{dry air}}$$

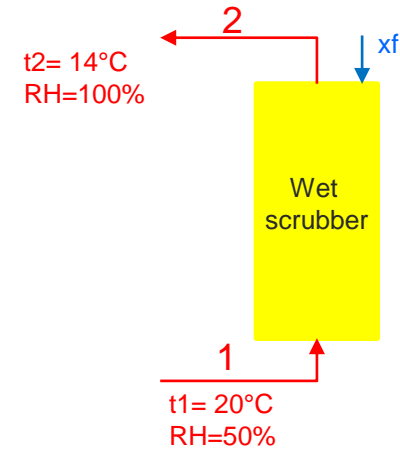
$$h_1 = 38.7 \text{ kJ/kg}; h_2 = 38.7 \text{ kJ/kg};$$

$$t_{\text{wb}} = 13.72 \sim 14^\circ\text{C} \text{ (from psychrometric calculator);}$$

$$x_2 = 0.0098 \text{ kg}_{\text{water vapor}} / \text{kg}_{\text{dry air}}$$

$$\text{H}_2\text{O abs for saturation: } 0.0098 - 0.0073 = 2.5 \text{ g w /kg dry air}$$

$$\Delta T_{\text{air flow}} = 14 - 20 = -6^\circ\text{C}$$



Water saturation pressure

Temperature [°C]	Water saturation pressure		
	[kPa], [100*bar]	[atm]	[psi]
0.01	0.61165	0.0060	0.088712
2	0.70599	0.0070	0.10240
4	0.81355	0.0080	0.11800
10	1.2282	0.0121	0.17814
14	1.5990	0.0158	0.23192
18	2.0647	0.0204	0.29946
20	2.3393	0.0231	0.33929
25	3.1699	0.0313	0.45976
30	4.2470	0.0419	0.61598
34	5.3251	0.0526	0.77234
40	7.3849	0.0729	1.0711
44	9.1124	0.0899	1.3216
50	12.352	0.122	1.7915
54	15.022	0.148	2.1788
60	19.946	0.197	2.8929
70	31.201	0.308	4.5253
80	47.414	0.468	6.8768
90	70.182	0.693	10.179
96	87.771	0.866	12.730
100	101.42	1.001	14.710
110	143.38	1.42	20.796
120	198.67	1.96	28.815
130	270.28	2.67	39.201
140	361.54	3.57	52.437
150	476.16	4.70	69.061
160	618.23	6.10	89.667
180	1002.8	9.90	145.44
200	1554.9	15.35	225.52

https://www.engineeringtoolbox.com/water-vapor-saturation-pressure-d_599.html

Psychrometric calculator

State 1

Inputs			Outputs	
Unit Chosen:	<input checked="" type="radio"/> SI	<input type="radio"/> IP	Atmospheric Press	1.01323875979 bar
Parameter Name	Value	Unit	Sat. Vapor Press.	23.3879775296 mbar
Dry Bulb Temp.:	20	C	Partial Vapor Press.	11.6939887648 mbar
Wet Bulb Temp.:	<input type="radio"/> 13.7249635224	C	Humidity Ratio	0.00726244220 kg/kg
Relat. Humidity:	<input checked="" type="radio"/> 50	%	Enthalpy	38.5419244498 kJ/kg
Dew Point Temp	<input type="radio"/> 9.30647760900	C	Specific Volume	0.83926354291 m3/kg
Altitude	0.0	m		
<input type="button" value="Calculate"/>			<input type="button" value="©"/>	

State 2

Inputs			Outputs	
Unit Chosen:	<input checked="" type="radio"/> SI	<input type="radio"/> IP	Atmospheric Press	1.01323875979 bar
Parameter Name	Value	Unit	Sat. Vapor Press.	15.7034731904 mbar
Dry Bulb Temp.:	13.724963	C	Partial Vapor Press.	15.7034731904 mbar
Wet Bulb Temp.:	<input type="radio"/> 13.724963	C	Humidity Ratio	0.00979169404 kg/kg
Relat. Humidity:	<input checked="" type="radio"/> 100	%	Enthalpy	38.5418732043 kJ/kg
Dew Point Temp	<input type="radio"/> 13.7581167961	C	Specific Volume	0.82505564440 m3/kg
Altitude	0.0	m		
<input type="button" value="Calculate"/>			<input type="button" value="©"/>	

$h_1 = h_2$
Enthalpy conservation

<http://www.sugartech.co.za/psychro/index.php>