

Basic Knowledge Of Compressed Air

1. Drain in the air pressure pipeworks

1. Why does drain appear?

The atmosphere contains moisture(vapor), according to the weather conditoin.

Since compressor inhales this atmosphere and compresses it into small volume, 1 m³ of the compressed air has a lot of vapor.

For example, 8 m³ atmosphere is necessary to get 1 m³ of 7kg/cm² compressed air, therefore 1 m³ of 7kg/cm² compressed air has eight times as much vapor as the atmosphere. The compressed air heated by adiabatic pressure by the atmosphere is cooled through the after cooler and over-saturated vapor is condensed and then drain appears. For example, the temperature of the air by the adiabatic pressure by the compressor: the temperature of the atmosphere +150°C The cooled temperature through the after cooler: 40°C

When the temperature of the compressed air is different from that of the surroundings, the compressed air in the air lines radiates heat, and inside the air equipments (air motor, air diver, nozzel, electromagnetic valve, etc.) the temperature is lowered by the adiabatic expansion and the temperature of compressed air also goes down. That is, the temperature is always lowered in the air lines and drain appears each time.

Drain hastens corrosion of the pipes, washes out the lubricating oil of

the electromagnetic valves, cylinders, ect. Causes slow operation, low efficiency, shorter life, and freezing problem in winter. In case of the air for paint work, it lowers the quality of the surface work and as to the air for the blow work, it causes rust on the machine parts and products.

2. Examples of calculation for the amount of drain

(1) The inhaling amount of vapor of the compressor

EX. The the temperature of the air: 32°C (saturated vapor 33.8g/m³)

- Reference figure 4 -

Relative humidity: 80%

Inhaling amount: 10 m³ /min

The amount of vapor in 1 m³ of the air is $33.8 \times 80 / 100 = 27 \text{g/m}^3$ and

the inhaling amount of vapor of the compressor per minute is 27

$\times 10 = 270 \text{g/min}$.

(2) The amount of drain through the after cooler

EX. The cooled temperature: 40°C (the amount of saturated vapor 51
g/m³)

Entrance pressure: 7kg/cm²

Converted by atmospheric pressure, the amount of the saturated vapor is

$51 / (7 + 1.033) = 6.4 \text{ g/m}^3$

It is condensed with more than 6.4 g/m³ vapor.

The inhaled air by the compressor has 27 g/m³ vapor, so when it is

compressed into 7kg/cm² , $27 - 6.4 = 20.6 \text{ g/m}^3$

20.6 g/m³ vapor is condensed and drain appears.

The amount of vapor which the compressor inhales (in case of relative humidity 100%) Unit: g/min

Temperature	Inhaling amount of the compressor N m ³ /min						
	1	2	3	5	10	20	50
30 °C	30.3	60.6	90.0	151.5	303.0	606.0	1515.0
20 °C	17.3	34.6	51.9	86.5	173.0	346.0	865.0
10 °C	9.4	18.8	28.2	47.0	94.0	188.0	470.0

-Figure 3-

(3) The amount of drain which appears in the air pressure lines.

EX. The surrounding temperature: 32 °C (the amount of the saturated vapor 33.8 g/m³)

Pressure in the lines: 7kg/m³

In converting the guage pressure 7kg/m³ air by atmospheric pressure, the amount of the saturated vapor at 32 °C is $33.8 / (7 + 1.033) = 4.3 \text{ g/m}^3$ As the amount of vapor is 6.4 g/m³ through the after cooler, it is $6.4 - 4.3 = 2.1 \text{ g/m}^3$

2.1g/m³ vapor is condensed and drain appears.

Therefore, when the air at 32 °C and relative humidity 80% is compressed by the compressor, 2.1 g/m³ drain appears in the lines as this example shows.

For example, if the amount of drain is calculated with the amount of recommended treatment air for each model of NEUTEK Extractor/Dryer, it

will be;

103	0.8g/minute	49g/hour
105	1.4g/minute	85g/hour
105-4	1.4g/minute	85g/hour
110	2.8g/minute	170g/hour
120	5.7g/minute	340g/hour
140	11.3g/minute	680g/hour
180	22.7g/minute	1.360g/hour

-Figure 1-

Even though about 5% is evaporated, a lot of drain is eliminated.

3. Dew point

At certain temperature the amount of vapor in the atmosphere exceeds the amount of the saturated vapor and water drops result. And when the amount of vapor in air is less than the saturated amount, water drops result at certain temperature by the fall the temperature. The temperature which results water drops is called dew point and shown in °C. Dew point of ordinary air is atmospheric dew point. For example, when the amount of vapor in air is 12.1 g/m³, atmospheric dew point is 14°C, according to the figure of the amount of the saturated vapor.

Compressed air has small volume compared with atmospheric condition because air is pressurized. The temperature which results water drops in that condition is called pressurized dew point.

When the amount of the saturated vapor at certain temperature in pressurized condition is returned to atmospheric condition, the volume of air is expanded and the content of vapor per 1 m³ air gets smaller as

the part of expansion. For example, as the amount of the saturated vapor of air which pressurized to 7kg/cm^3 is 30.3 g/m^3 at 30°C (pressurized dew point), converted by atmospheric pressure, the volume becomes about eight times ($7+1.033$) and the following calculating is used.

$$30.3 / (7 + 1.033) = 3.8\text{ g/N m}^3$$

N m^3 shows the unit of air volume in the atmospheric condition and N is pronounced (norumaru).

Conversion of pressurized dew point and atmospheric dew point is done by using the conversion figure (the attached paper).

2. Humidity of the atmosphere

The composing rate of the elements of air, oxygen nitrogen, carbon dioxide and so on are almost fixed, but the content rate of vapor differs depending on the weather condition.

There are two following ways to show the content rate of vapor.

1. Relative humidity

Air touching the surface of water or air in the condition of fog is saturated in vapor. At certain temperature there is a limit to the amount of vapor which air can contain and when the limit is exceeded, water drops appear. the amount of the vapor in that condition is called the amount of the saturated vapor and the higher the temperature is, the more vapor can be contained. Percentage of the amount of vapor contained in air to the amount of the saturated vapor at 20°C is 17.3g to 1 m^3 air, but

supposing that it is 12.1g, it will be $12.1/17.3 \times 100 = 70\%$ This numerical value is relative humidity.

2. Absolute Humidity

Absolute Humidity is the the amount of vapor contained in 1 m^3 air which is shown in gram, without cincering the temperature.

As the higher the temperature is, the more the amount of the saturated vapor is, even when relative humidity is 100%, there is some difference between summer and winter in regards to absolute humidity.

For example, when relative humidity is 100%

at 30°C absolute humidity is 30.3 g/m^3

at 5°C absolute humidity is 6.8 g/m^3 - Reference figure 4 -

When the compressor inhales 10 m^3 air every minute, it inhales

at 30°C 303g

at 5°C 303g

moisture in the example above.

KUALA LUMPUR /MNTH	TEMP $^\circ\text{C}$	HUMIDITY %	WATER g/m^3	SINGAPORE/MNTH	TEMP $^\circ\text{C}$	HUMIDITY %	WATER g/m^3	BANGKOK /MNTH	TEMP $^\circ\text{C}$	HUMIDITY %	WATER g/m^3
1	26.1	79	19.3	1	25.6	84	20.0	1	26.2	69	17.0
2	26.5	77	19.3	2	26.1	83	20.3	2	27.7	75	20.1
3	26.8	80	20.3	3	26.6	83	20.9	3	29.2	75	21.8
4	26.8	83	21.1	4	27.0	84	21.6	4	30.3	76	23.4
5	27.2	82	21.3	5	27.3	84	22.0	5	29.7	80	23.9
6	26.9	82	21.0	6	27.2	83	21.6	6	29.1	79	22.8
7	27.5	81	20.3	7	26.9	83	21.2	7	28.7	80	22.6
8	26.4	82	20.4	8	26.8	82	20.8	8	28.5	82	22.9
9	26.3	83	20.5	9	26.7	82	20.7	9	28.1	84	23.0
10	26.2	84	20.6	10	26.6	84	21.1	10	28.0	83	22.6
11	26.1	85	20.8	11	26.1	86	21.0	11	27.1	78	20.2
12	26.9	83	20.1	12	25.6	87	20.7	12	26.0	74	18.0
MEAN	26.5	81	20.3	MEAN	26.5	84	21.0	MEAN	28.3	78	21.6

Relative humidity is a little higher from June to October, on the contrary, there is a great difference between summer and winter in regards to absolute humidity.

HONG KONG

MONTH	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)
1	15.6	66
2	15.9	77
3	18.4	80
4	22.1	84
5	26.0	79
6	27.7	82
7	28.6	80
8	28.2	80
9	27.5	77
10	25.0	73
11	21.3	72
12	17.6	69
MEAN	22.8	77

JAKARTA

MONTH	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)
1	26.2	86
2	26.3	84
3	26.9	83
4	27.5	82
5	27.6	80
6	27.2	78
7	26.8	75
8	27.0	74
9	27.4	73
10	27.6	75
11	27.3	78
12	26.8	82
MEAN	27.0	77

Dew point -the amount of vapor figure

According to the figure made by prof. Max Rovitte of Berlin Univ. 1941

(Unit: g/ m³)

	0°C	1	2	3	4	5	6	7	8	9
90°C	420.1	433.6	448.5	464.3	480.8	486.6	514.3	532.0	550.3	569.7
80°C	290.8	301.7	313.1	325.3	337.2	349.9	362.5	375.9	389.7	404.9
70°C	197.0	204.9	213.4	222.1	231.1	240.2	249.6	259.4	269.7	280.0
60°C	129.8	135.6	141.5	147.6	153.9	160.5	167.3	174.2	181.6	189.0
50°C	82.9	86.9	90.9	95.2	99.6	104.2	108.9	114.0	119.1	124.4
40°C	51.0	53.6	56.4	59.2	62.2	65.3	68.5	71.8	75.3	78.9
30°C	30.3	32.0	33.8	35.6	37.5	39.5	41.6	43.8	46.1	48.5
20°C	17.3	18.3	19.4	20.6	21.8	23.0	24.3	25.7	27.2	28.7
10°C	9.4	10.0	10.6	11.3	12.1	12.8	13.6	14.5	15.4	16.3
0°C	4.85	5.19	5.56	5.95	6.35	6.80	7.26	7.75	8.27	8.82
0°C	4.85	4.52	4.22	3.93	3.66	3.40	3.16	2.94	2.73	2.54

-10°C	2.35	2.18	2.02	1.87	1.73	1.60	1.48	1.36	1.26	1.16
-20°C	1.067	0.982	0.903	0.829	0.761	0.698	0.640	0.586	0.536	0.490
-30°C	0.448	0.409	0.373	0.340	0.309	0.281	0.255	0.232	0.210	0.190
-40°C	0.172	0.156	0.141	0.127	0.114	0.103	0.093	0.083	0.075	0.067
-50°C	0.060	0.054	0.049	0.043	0.038	0.034	0.030	0.027	0.024	0.021
-60°C	0.019	0.017	0.015	0.013	0.011	0.0099	0.0087	0.0076	0.0067	0.0058
-70°C	0.0051									

This figure shows how many grams of vapor 1 m³ air can contain under the atmospheric pressure. The vertical axis shows the temperature divided into every 10°C and the horizontal axis shows the temperature into every 1°C. To find the amount of water at 45°C, find 40°C on the vertical axis first and move it to the right, then come down from the top at 5°C. The intersection shows the amount of water at 45°C. It is 65.3g/ m³ .

EX. 1. when the temperature of air is 35°C, relative humidity is 100 and the pressure is atmospheric, the amount of vapor in 1N m³ in 39.5g.

EX. 2. Supposing that under the condition of EX. 1. and only relative humidity becomes 75%, 1N m³ air contains $39.5 \times 0.75 = 29.6$ g water.

EX. 3. Supposing that under EX. 1. Condition and the pressure becomes 5kg/c m² G (gauge pressure), 1N m³ air contains $39.5 \div (5 + 1.033) = 6.6$ g water.

Therefore, with this figure it is easy to calculate how many grams of water a compressor inhales a day and how much water is eliminated by after cooler, air filter, pipes, tanks or cooling air dryer ect.

Pressurized dew point atmospheric dew point conversion figure

Then figure above is used to convert atmospheric dew point into pressurized dew point and vice versa.

For example, when the atmospheric dew point at the outlet of cooling air dryer is measured, it shows -15°C . If the air pressure of the cooling air dryer is $4\text{kg}/\text{c m}^2\text{G}$, find -15°C in this figure and go up along the line, then find the intersection with $4\text{kg}/\text{c m}^2\text{G}$. The temperature of Pressurized dew point can be found by moving the intersection to the left horizontally. In this case it 6°C . This means that as long as the pipes are not cooled down below 6°C , compressed air through cooling air dryer does not result water drops. Do just the opposite to find atmospheric dew point from Pressurized dew point.

DEW POINT							
DEW POINT $^{\circ}\text{C}$	g m^3	DEW POINT $^{\circ}\text{C}$	g m^3	DEW POINT $^{\circ}\text{C}$	g m^3	DEW POINT $^{\circ}\text{C}$	g m^3
+100	588.208	58	118.199	+16	13.531	-25	0.55
99	569.071	57	113.130	15	12.739	26	0.51
98	550.375	56	108.200	14	11.987	27	0.46
97	532.125	55	103.453	13	11.276	28	0.41
96	514.401	54	98.883	12	10.600	29	0.37
95	497.209	53	94.483	11	9.961	30	0.33
94	480.394	52	90.247	10	9.356	31	0.301
93	464.119	51	86.173	9	8.784	32	0.271
92	448.308	50	82.257	8	8.243	33	0.244
91	432.885	49	78.491	7	7.732	34	0.220
90	417.935	48	74.871	6	7.246	35	0.198
89	403.380	47	71.395	5	6.790	36	0.178
88	389.225	46	68.056	4	6.359	37	0.160
87	375.471	45	64.848	3	5.953	38	0.144
86	362.124	44	61.772	2	5.570	39	0.130
85	340.186	43	58.820	1	5.209	40	0.117
84	336.660	42	55.989	0	4.868	41	0.104
83	324.469	41	53.274			42	0.093
82	311.616	40	50.672	-1	4.487	43	0.083
81	301.186	39	48.181	2	4.135	44	0.075
80	290.017	38	45.593	3	3.889	45	0.067
79	279.278	37	43.508	4	3.513	46	0.060
78	268.806	36	41.322	5	3.238	47	0.054
77	258.827	35	39.286	6	2.984	48	0.048

76	248.840	34	37.229	7	2.751	49	0.043
75	239.351	33	35.317	8	2.537	50	0.038
74	230.142	32	33.490	9	2.339	51	0.034
73	221.212	31	31.744	10	2.156	52	0.030
72	212.648	30	30.078	11	1.96	53	0.027
71	204.286	29	28.488	12	1.80	54	0.024
70	196.213	28	26.970	13	1.65	55	0.021
69	188.429	27	25.524	14	1.51	56	0.019
68	188.855	26	24.143	15	1.38	57	0.017
67	173.575	25	22.830	16	1.27	58	0.015
66	166.507	24	21.578	17	1.15	59	0.013
65	159.654	23	20.386	18	1.05	60	0.011
64	153.103	22	19.252	19	0.96	65	0.0064
63	146.771	21	18.191	20	0.88	70	0.0033
62	140.659	20	17.148	21	0.80	75	0.0013
61	134.684	19	16.172	22	0.73	80	0.0006
60	129.020	18	15.246	23	0.66	85	0.00025
59	132.495	17	14.367	24	0.60	90	0.0001

NOTES

Air at 25C, 100% saturated contains 22, 830gm of water per Mof Air. (Thies corresponds to a dewpoint of +25C).

If you wish only 0, 117 gm/m³ of water remaining (corresponding to a dewpoint of -40C), The water taken out in the dryer is 22, 713 gm/m³ .