Industrial Dehumidifier Sizing

Introduction

This application note will highlight the primary sources of moisture in industrial facilities. Different methods of solving moisture problems are outlined along with formulas for estimating the moisture content. A questionnaire is incorporated to obtain the minimum information required for proper sizing of dehumidification equipment.

Dry Air

Quality and productivity are an ever increasing concern for today's businesses. The effect moisture laden air has on these two concerns is becoming more important as industry strives for tighter operational tolerances. Manufacturers must insure that products maintain specific quality specifications and efficiency is maintained throughout the four seasons.

There are many commercial and industrial applications which require dry air. To eliminate the moisture problem at a reasonable cost, the specifier needs to know how much moisture is present, how did it get in the facility and how to select the proper dehumidification system.

Methods of Drying Air

There are several methods of drying air. Each method has advantages and disadvantages. The common types are:

- **Make-up air method**
- **Compression**
- **Refrigerated dehumidification**
- **Desiccant dehumidification**

The fist method uses the principle of dilution, removing a portion of the moisture laden air from a space and replacing it with drier air. The net result is a lower average moisture content. This method is relatively inexpensive to install, but relies on the fact that drier air is available. Since the most common source is outside make up air, this method is difficult to apply in summer months and expensive to operate in winter due to heating costs.

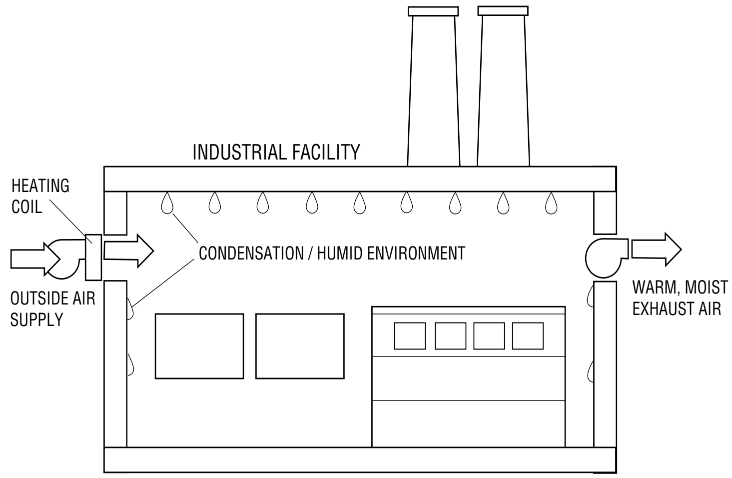

Figure 1 - Make-up Air Method

Using compression to dry air is effective when small quantities are needed. When air is compressed, the dew point is raised, that is, the temperature at which water vapor will condense is raised. This method has high installation and operational costs and is most common when less than 100cfm of dry air is required.

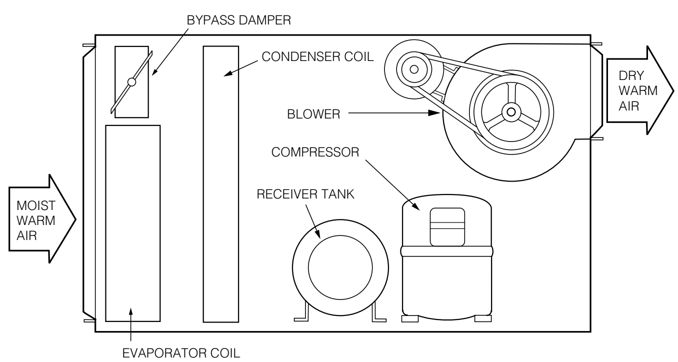

Figure 2 - Refrigeration Dehumidifier Schematic

Refrigeration dehumidifiers reduce the moisture in the air by passing the air over a cold surface, removing the moisture by condensation. A detailed discussion on this technique is explained in Desert Aire Technical Bulletin #1. This method is effective for desired conditions down to 45 percent RH for standard applications. Specially designed systems can achieve dew points as low as 35°F. This method has moderate capital costs and can recover much of the latent energy thus offsetting operating costs.

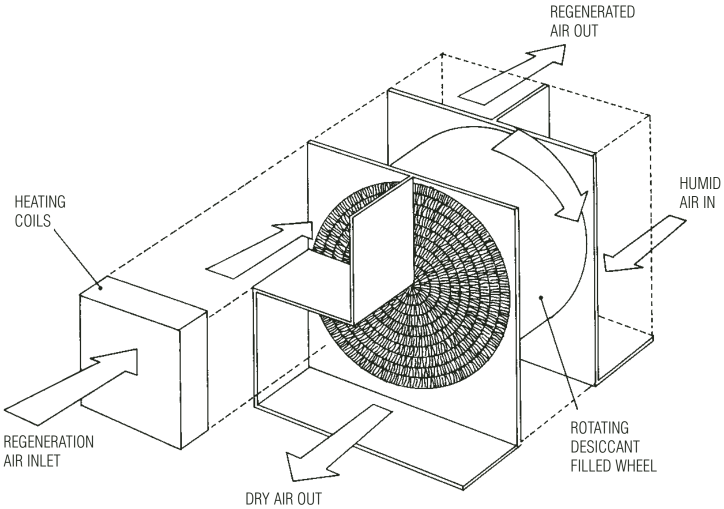

Figure 3 - Desiccant Dehumidifier Schematic

Desiccant dehumidifiers use special materials that absorb or hold moisture. The material is unique in that it does not change its size or shape when acquiring the moisture and can be regenerated by applying heat. This technique is used effectively to dry air in the range of 0 to 50%RH. It has a relatively expensive capital expense as well as a high operational cost.

Sources Of Moisture

There are many sources of moisture in a facility. A list of the Common ones follows:

- Infiltration
- Permeation
- Ventilation and make-up air
- Door and window openings
- People
- Processes
- Product

Infiltration and Permeation

Infiltration and permeation are often considered the same thing. Infiltration is the movement of water vapor through cracks, joints and seals. Permeation is the migration of water vapor through materials such as brick and wood. One of the physical laws of nature states that all conditions must be balanced. In the case of water vapor the partial pressure of the water vapor must be the same on either side of a barrier. For this reason water vapor will migrate through brick walls to get to the less humid side. The rate of migration in an unbalanced situation exceeds the rate of air through cracks and seals and will in effect find a path to attempt to balance partial pressures.

Moisture load in a space due to infiltration and permeation is not easily measured. Factors such as the actual moisture deviation, materials of construction, vapor barrier and room size all have an effect on the vapor migration. Desert Aire has used some basic models to make assumptions to estimate moisture infiltration and permeation.

The Combined infiltration and permeation load can be approximated from the following equation:

$$\text{Lb/HR Moisture} = \frac{V \times AC \times GR \times MF \times CF}{7000 \times 13.5}$$

Where

- V = Volume of room to be conditioned (cu. ft.)
- AC = Air change factor from Table 1
- ΔGR = The deviation from the outside to the desired conditions (grains/LB)
- MF = Migration factor is ΔGR ÷ 30 (min. value = 1.0)
- CF = Construction factor from table 4
- 13.5 = Conversion factor for CU. Ft./LB.
- 7000 = Conversion factor for GR/LB

According to ASHRAE, the median number of air changes per hour is 0.5. The actual number of air changes is influenced by several factors, the most dominate being the size of the room. The larger the room the longer it takes to convert one volume. The following table compensates for the reduction in infiltration /permeation on larger or smaller volumes.

VOLUME (CU FT.)	AC	VOLUME	AC
Less Than 10,000	0.65/HR	40,001-60,000	.45
10,001-20,000	0.60	60,001-100,000	.40
20,001-30,000	0.55	100,000-200,000	.35
30,001-40,000	0.50	Greater than-200,000	.30

Table 1 - Air Changes for Specific Volumes

The rate of infiltration is a function of the magnitude of imbalance between the outside absolute humidity and that inside the conditioned space. The greater the difference, the greater the driving force to make the vapor pressures equal. The migration factor compensates for this influence.

The ΔGR (grain/lb) deviation must be obtained from the Psychrometric chart. By locating the outside and inside conditions on the chart an absolute humidity in grains/lb can be obtained. The formula uses the difference in grain/lb between these two conditions. Refer to Table 2 and 3 for humidity values for specific locations and inside design conditions. For other values the Psychrometric chart must be utilized. Please refer to Desert Aire Technical Bulletin Number 3 if assistance is required to read the chart.

Another primary factor is the amount of moisture that is allowed to permeate through the walls, floor and roof. The construction factor takes into account the effect good vapor barriers and construction materials will have on the moisture migration. Table 4 gives factors for common construction materials. This factor will vary between 0.3 and 1.0. A composite wall must be modeled and a factor estimated.

		RELATIVE HUMIDITY			
		40%	50%	60%	70%
DRY BULB	55	25*	32*	40*	45
	60	31*	39*	46	54
	65	37*	46	55	65
	70	42	55	66	78
	75	53	66	78	91
	80	62	77	93	108
	85	72	91	109	128
	90	85	108	128	152

Table 2 - Grains/LB at specific temperature and RH

*Below refrigerant dehumidification capability

DESCRIPTION	CF FACTOR
Frame construction, no vapor barrier	1.00
Masonry, no vapor barrier	1.00
Masonic, vapor proof paint	.75
Plastic modules	.75
Frame construction, vapor proof paint	.75
Frame construction, mylar vapor wrap	.50
Sheet metal, good seals	.50
Glass	.30

Table 4 - Construction Factor

Door Openings

Another source of moisture is the opening of doors and windows to the conditioned space or other openings such as conveyor passages. In these cases, the amount of moisture is directly proportional to the frequency of the opening, the difference in indoor and outdoor moisture content and the wind velocity at the opening. The wind velocity will be the most difficult to take into account since it will vary depending on the location of the opening with respect to the wind source. Local weather stations can provide details on the normal prevailing direction and speed. However, a guideline is 12 CFM of outside air per square feet of opening.The amount of air can be estimated by the following formula.

$$\text{LB/HR} = \frac{\text{AREA x OPEN x } \Delta\text{GR x 12}}{\text{7000 x 13.5}}$$

Where:

AREA = Surface area of opening (Sq. Ft.)

OPEN = Minutes area is open per hour

ΔAG = The deviation from the outside to the desired conditions (grains/LB)

12 = Estimated ingress of moisture (CFM/Sq.Ft.)

13.5 = Conversion factor for CU.FT./LB

7000 = Conversion factor for GR/LB

When this equation is used for a fixed opening such as a window, the minutes open/hr will equal 60.

OUTSIDE AIR MOISTURE CONTENT TO BE REMOVED											
	City	Gr.		City	Gr.		City	Gr.		City	Gr.
AK	Anchorage	59	IN	Fort Wayne	121	NV	Las Vegas	82	TX	Lubbock	111
AL	Birmingham	126		Indianapolis	130		Reno	59		Odessa	109
	Mobile	137	KS	Wichita	120	NY	Albany	109		San Antonio	128
AR	Little Rock	132	KY	Louisville	125		Buffalo	108	UT	Salt Lake City	76
AZ	Phoenix	102	LA	Baton Rouge	136		New York	121	VA	Norfolk	124
CA	Long Beach	91		New Orleans	143		Rochester	116		Richmond	130
	Los Angeles AP	96		Shreveport	134		Syracuse	110		Roanoke	113
	Sacramento	72	MA	Boston	112	OH	Cincinnati	120	VT	Burlington	105
	San Diego	103	MD	Baltimore	120		Cleveland	116	WA	Seattle	71
	San Francisco AP	67	ME	Caribou	102		Columbus	119		Spokane	61
	Santa Barbara	85		Portland	106	OK	Oklahoma City	125		Yakima	63
	Stockton	72	MI	Detroit	114	OR	Eugene	73	WI	Green Bay	117
CO	Denver	78		Flint	117		Portland	72		Madison	115
CT	Hartford	111		Grand Rapids	116	PA	Erie	114		Milwaukee	115
DC	Washington Nat'l	129		Sault St. Marie	102		Philadelphia	124	WV	Charleston	120
DE	Wilmington	121	MN	Duluth	98		Pittsburgh	116	**CANADA**		
FL	Daytona Beach	137		Rochester	120		Scranton	114			
	Fort Myers	143		St. Paul	114	RI	Providence	114	AL	Calgary	69
	Jacksonville	134	MO	Kansas City	126	SC	Charleston	136	BC	Vancouver	76
	Miami	137		St. Louis	132		Columbia	122	MN	Winnipeg	97
	Orlando	136	MS	Jackson	136	SD	Sioux Falls	119	NB	Saint John	87
	Pensacola	143		Meridian	127	TN	Bristol	118	NF	St. John's	89
	Tallahassee	136	MT	Billings	70		Chattanooga	126	NS	Halifax	100
	Tampa	136	NC	Cape Hatteras	142		Knoxville	124	ON	Ottawa	101
GA	Atlanta	123		Charlotte	122		Memphis	132		Sudbury	93
	Augusta	128		Raleigh	126		Nashville	126		Thunder Bay	91
HI	Honolulu	117	ND	Fargo	109	TX	Brownsville	136		Toronto	108
IA	Des Moines	122	NE	Omaha	125		Corpus Christi	141		Windsor	115
	Davenport/Moline	127	NH	Concord	109		Dallas	121	QC	Montreal	106
ID	Boise	59	NJ	Atlantic City	123		El Paso	99		Quebec	100
IL	Chicago	118		Newark	121		Fort Worth	123	SK	Regina	80
	Rockford	119	NM	Albuquerque	80		Houston	135			

Table 3 - Geographic Outdoor Design Criteria (ASHRAE FUNDAMENTALS 1%)

Product, Process and People

The three "P's", product, process and people must also be included in the moisture evaluation. If the product has an affinity for water, then it may also release the water in the conditioned room. For example, wet wood brought into a conditioned warehouse will release the water at a specific rate. This can be determined by measuring the products weight loss over time.

The process itself may generate moisture. If there are open water tanks or cooking vessels, they will add moisture. A model must be developed for each process.

In the case of, open water tanks, the evaporation rate can be calculated with the following equation.

$$LB/HR = 0.1 \times AREA \times (VP_{H2O} - VP_{AIR})$$

Where:

Area = Surface area of water (square feet).

VP_{H2O} = Vapor pressure of water at water temperature

VP_{AIR} = Vapor pressure of air at it's corresponding dew point.

The above equation assumes 10 to 30 FPM air velocity in room. Vapor pressures can be obtained from technical publications. Consult Desert Aire if you need assistance. Finally people give off moisture. This is a function of the number of people and their activity: a worker lifting boxes will generate 4 to 8 times the moisture of a worker at a lab bench. ASHRAE'S data on the amount of water added per person is reproduced in table 5.

WORK TYPE	EVAP. RATE
Seated in theater	0.10 Lb/Persons/HR
Office work, light work	0.200
Medium factory work	0.475
Heavy factory work	0.965
Athletics	1.095

Table 5 - Evaporation Rates of People

Ventilation and Make-up Air

If the facility is using fresh outside make-up air for ventilation as required by some building codes, then this air can contribute to the moisture load. This is especially important in the summer months when high humidity is common. As with the calculation for infiltration the difference in absolute humidity must be used, along with the volume of make-up air being brought in by the air handling system. The formula for calculating moisture load is:

$$LB/HR\ Moisture = \frac{CFM \times \Delta GR \times 60}{7000 \times 13.5}$$

CFM = Volume of outside air introduced

ΔGR = The deviation from the outside to the desired conditions (grains/LB)

60 = Conversion factor for min/hr

13.5 = Conversion factor for CU.FT./LB

7000 = Conversion factor for GR/LB

Conclusion

To properly select and size a dehumidification system to condition a facility requires careful planning. The engineer or facility operator must specify the operating conditions that must be maintained. Then he must evaluate all of the potential sources of water and the outside ambient conditions. This information can then be used to size the system. The enclosed worksheet is provided to organize the collection of minimum information required for selection and sizing. The formulas will provide an approximation of the moisture load. An engineer should be consulted to confirm that the assumptions are appropriate for the application.

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