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Technical Resource Center

Part Four

Calculating the Various Moisture Loads

The following methods have been used successfully to calculate vapor loads: replacing the extensive calculations and laboratory tests that might otherwise be required when a designer considers a new space humidity problem or application.

Table I: Recommended Design Outside Moisture Level

Design		Design	
Outside Wet Bulb	Specific Humidity	Outside Wet Bulb	Specific Humidity
°F	gr/lb	°F	gr/lb
81	149	75	121
80	143	74	117
79	139	73	113
78	134	72	109
77	130	71	106
76	125	70	102

Table II: F₁ Factor for Grain Difference

gr/lb Difference	F ₁ Factor
35	1.0
40	1.12
50	1.35
60	1.59
70	1.82
80	2.06
90	2.29
100	2.53
110	2.76
120	3.00

Space moisture load is a combination of permeation and infiltration and both will be encountered in determining the load. Permeation is a straight line function of the difference in interior and exterior vapor pressures (determined by gr/lb). As shown in Table III, infiltration, represented in air changes per hour is not straight line because of the two factors involved:

1. Each pound of air entering the space will impose a moisture load determined by the difference in interior and exterior moisture content.
2. Since the vapor pressure differs as the moisture content, the vapor will move at a higher velocity than the air.

The combination of the two factors, results in the space moisture load increasing at an ever increasing rate as the difference between the interior and exterior moisture contents increase.

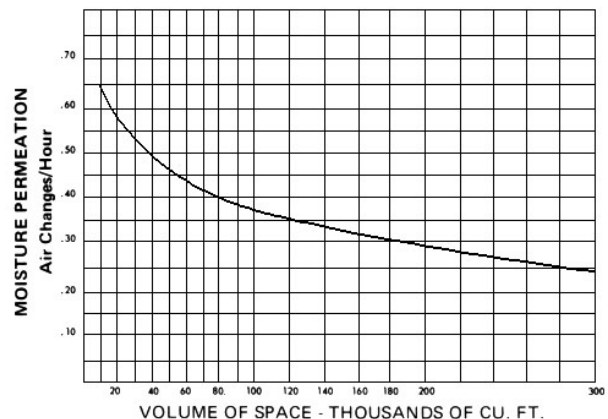
In view of the above, the F-1 factor is used to adjust for the increased vapor velocity. Therefore, the combination of the F-1 and F-2 factors represent the space moisture load anticipated from both permeation and infiltration.

Actual data from moisture loads entering a space through walls, floors, and ceiling are available for various moisture loads and classes of construction.

For standard types of construction, Bry-Air has determined values for calculating the moisture load entering a space at controlled humidity levels. Usually these calculations are relatively easy. The following tables are aids for load calculations.

Outside humidity levels shown in Table I are deliberately higher than data for design specifications. This compensates for days when the design wet-bulb temperatures are reached and the design dry-bulb temperatures are lower than expected (thus creating higher total humidity). Use the area design wet-bulb and the specific humidity figures shown here to accurately rate the moisture control situation. Further information on design can be found in the ASHRAE Fundamentals Handbook, "Weather Data and Design Considerations".

Table III: F₂ Factor for Space Permeation





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Table IV

F₃ Factors For Construction		F₄ Factors For Vapor Barriers	
Masonry or Frame Construction	1.0	Laminated, Mylar - metallic or polyethylene film	0.5
Sheet metal, steel welded	0.3	Two layers edge sealed moisture paper	0.67
Module panel, caulked and sealed	0.5	Two coats vapor proof paint	0.75

If the product of F₃ × F₄ is less than 0.5, use 0.5. If the room is completely vapor proofed, with continuous vapor barrier under the floor (or of allmetal, welded material) the factor may be reduced to 0.3.

Calculate the Permeating Load through a Structure

To determine the grains of moisture penetrating the construction into a controlled space, use the following calculation.

$$\frac{V}{C} \times \Delta G \times F_1 \times F_2 \times F_3 \times F_4 = \text{Grs/hr. (To determine grains/minute divide answer by 60).}$$

= Amount of vapor able to permeate the closed space through construction and vapor barriers.

- V = volume of controlled space in question - ft.³
- C = 14 = constant used to translate ft.³ to pounds. This constant is used regardless of the density of the air.
- ΔG = difference between the grs/lb of outside air and the grs/lb desired in the controlled space.
- F₁ = moisture difference factor (Multiplier from Table II).
- F₂ = Permeation factor (Multiplier from Table III).
- F₃ = Construction factor - Table IV
- F₄ = Barrier Factor - Table IV { See note with Table IV

The above equation can be used to solve a typical example as follows:

Problem - Find the amount of moisture that will permeate the room defined below.
 Sample Calculation - Space to be controlled:

- (1) Room with 12" masonry walls.
- (2) Two coats of aluminum paint as vapor barrier.
- (3) Volume of room - 22,000 ft.³
- (4) Outside Design: 95°F db 77°F wb (Table I Shows 130 gr/lb)
- (5) Required - To hold in room - 40 gr/lb

$$\frac{V}{C} \times \Delta G \times F_1 \times F_2 \times F_3 \times F_4 = \text{Grains per hour.}$$

- V = 22,000
- C = 14
- ΔG = 130 - 40 = 90 Problem stipulates 40 gr/lb in the room; therefore, 130 - 40 = 90.
- F₁ = 2.29 From Table II (Factor for a moisture difference of 90 gr/lb).
- F₂ = 0.58 From Table III Locate 22,000 on bottom line. Travel up and read curve at 0.58.
- F₃ = 1.0 From Table IV
- F₄ = .75 From Table IV - (Factor for 2 coats of paint)

$$\frac{22,000}{14} \times 90 \times 2.29 \times 0.58 \times 1.0 \times 0.75 = 140,884 \text{ grs/hr}$$

$$\frac{140,884}{60} = 2348 \text{ grs/min}$$



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Moisture through Intermittent Openings

When such openings as service or personnel doors are opened periodically, moisture-laden air can enter the conditioned space. Also, vapor is constantly seeking drier space and will seep around and through doors, even when they are closed.

Obviously the first precaution is to assure that openings are adequately vapor-sealed. Then the drying equipment must deal with the moisture load that comes into a controlled space when the door is open. Assuming that the door is open only for short periods, calculate the moisture load as follows:

$$O_{hr} \times \frac{A}{C} \times \Delta G \times F_1 = \text{Grains}$$

O_{hr} = number of times each hour the door is opened. (If unknown assume personnel doors to be opened 2 times/hr for every occupant.)

A = area of the door opening in square feet.

C = 7 = constant

ΔG = difference in specific humidity in grs/lb between controlled space and the adjacent space.

See Table I for outside w_b to determine adjacent specific humidity.

F_1 = factor from Table II for moisture difference.

Examples:

Door area - 3' x 7'

Door opens - 6 times each hour

Moisture difference - 90 grs/lb

Solution:

$$O_{hr} \times \frac{A}{C} \times \Delta G \times F_1 = \text{grains per hour of additional load}$$

$$6 \times \frac{21}{7} \times 90 \times 2.29 = 3710 \text{ grains per hour added to controlled space.}$$

Note that if the door is open for longer periods, use the calculation scheme below.

Moisture Through Fixed Openings (Conveyors, Open Windows, Etc.)

Calculate the amount of moisture that travels through a fixed opening from a wet space to a drier space as follows:

$$\frac{A \times 300}{C \times D} \times \Delta G \times F_1 = \text{grains per hour of additional load}$$

Where

A = Area of fixed opening in square feet,

300 = Experimental constant – velocity of vapor, ft/hr at 35 gr difference,

C = 14 = constant factor to translate ft.3 to pounds,

D = feet = depth of opening,

ΔG = grains = difference in grs/lb between wet space and drier space,

F_1 = Moisture Difference Factor from Table II.



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Example:

Conveyor opening	2 sq ft
Depth of opening	1.5 sq ft
Moisture difference	90 grains

Solution:

$$\frac{A \times 300}{C \times D} \times \Delta G \times F_1 = \text{grains per hour of additional load}$$

$$\frac{2 \times 300}{14 \times 1.5} \times 90 \times 2.29 = 5889 \text{ grains per hour}$$

Moisture Originating In the Controlled Space

Moisture or vapor originating in the controlled space comes from any of several sources, depending on the intended use for the space. Three basic sources of moisture are:

- Population load, including people and animals
- Product load, brought in by the product
- Process load.

Population load.

People working in an area add moisture to the air because of breathing and the evaporation of perspiration. When animals occupy the controlled space, moisture release is contributed by their excrement.

How much moisture do people or animals add to a controlled space? Such factors as the level of activity and the ambient temperature, atmospheric pressure, and humidity are well documented. (See Appendix 3, page 40)

For animals, weigh the amount of water consumed during a given period and assume that much water will be eliminated.

Product load.

Any material manufactured in a controlled area can bring moisture with it and then release the moisture into the work area. Material brought into a warehouse tends to become drier; it gives up moisture over a period of time and loads the drying equipment accordingly.

All materials should be suspect. For example, most metals bring very little moisture, but nonmetals can carry surprisingly large amounts of water. The material's supplier should have information on its moisture carrying characteristics.

If such data are unavailable, a simple test should prevent an unexpected and substantial moisture load problem. Place a sample of the material in a small, dry container. Or place some material in a tall hopper and blow air over it to dry it. Measure the moisture loss over an appropriate time interval to determine its dwell time, or how fast it gives up moisture. In some cases, a small pilot plant can be used to acquire definite data.

Process load.

The manufacturing process itself may expel moisture into the atmosphere of a controlled space. Open tanks or trays of liquid will add to the moisture load.

Other contributors include open steam exhausts, unvented combustion cycles, and aging or curing cycles.



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Ventilating Air-Vapor Load (Vapor Brought In With Outside Air)

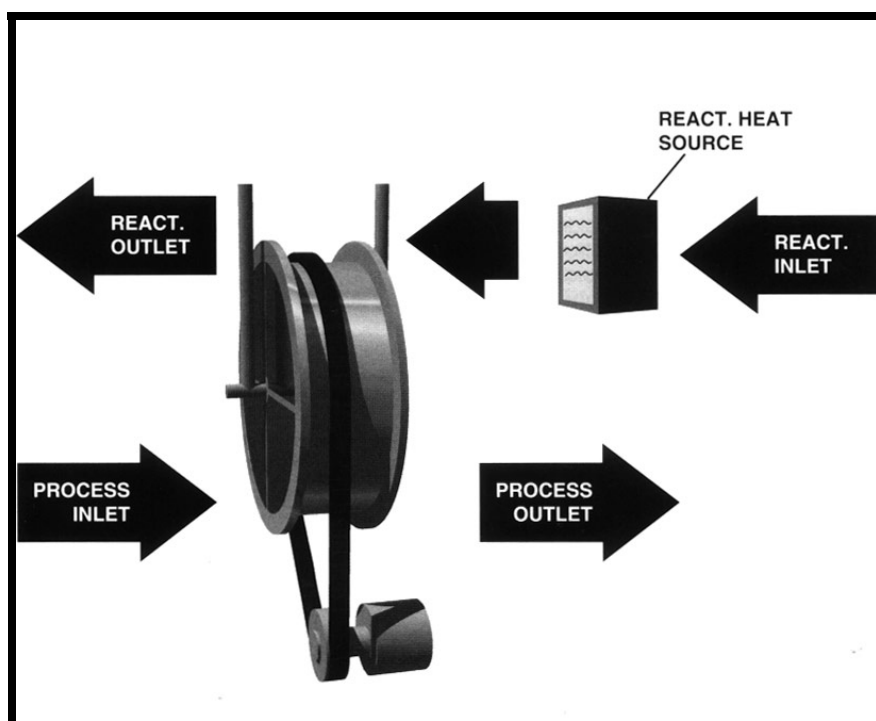
Ventilating or make-up air from the outside contains moisture that must be removed. Some designers add this moisture load to the total calculated internal load to determine the required capacity of the drying equipment.

However, Bry-Air recommends this air not be considered part of the internal load. Rather, it should be considered at its point of entry.

If this added, or make-up air from outside mixes with the return air and all go through the dehumidifier, then it is not added to the internal moisture load. But if only part of this outside/return air mixture passes through the dehumidifier, then the part bypassing the dehumidifier must be added to the internal load of the room.

The added air is only part of the total air used in controlling space humidity. Since it rarely gets into the controlled space without first going through the dehumidifier, consider it at its point of entry-at the dehumidifier.

Among the normal elements of an air drying system, the air entering the drying equipment is a mixture of return air from the controlled space and make-up air from the outside. The temperature and moisture content of this mixture depend on its two contributing air streams.



Moisture-laden air enters through the process inlet and moves through the Brysorb Plus™ desiccant media. The desiccant adsorbs the water vapor and the dehumidified air is then delivered through the process outlet directly into the controlled space or air stream. Then, as the desiccant media rotates into the reactivation air stream, the hot air entering through the reactivation inlet drives off the moisture and exhausts it into the atmosphere. After reactivation the hot, dry desiccant rotates back into the process air stream where a small portion of the process air cools the desiccant so that it can begin the adsorption process all over again.