

Part Five

Sizing the Dehumidifier

When deciding what size dehumidifier to use, remember that controlled space requirements sometimes exceed the anticipated design peak load. Unusual and unforeseen humidity loads — such as from abnormal weather conditions or the introduction of high-moisture content raw materials — can burden the drying equipment. Here we present a number of issues that must be considered in approaching and solving specific drying problems. Six typical humidity control examples are presented:

- Food and drug manufacturing, specifically raw materials and processing equipment (Production of hard candy)
- Storage or equipment areas (Standby warehouse)
- Product drying
- Controlled humidity and temperature areas
- Specific purposes for dry air production
- Prevention of condensation (Water treatment plant)

Example I: Production of Hard Candy

During candy and cough drop production, the material is in a plastic state. It must flow and be shaped by stamping machines. If the presence of excess moisture causes the material to become sticky, it will not flow freely and it will adhere to the stamping machine.

To eliminate this material and equipment problem, dry the surrounding air.

Physical Facts

1. Area to be conditioned - 60' x 42' x 16
2. Outside design condition - 95 F db*; 75 F wb*
3. Controlled space requirement - 75 F db; 35 percent rh
4. Physical openings - 1 door (6' x 7'); opened 6/hr
5. Number of people working in area - 10
6. Construction - 8" masonry
7. Make-up air specified by owner - 350 cfm.

* db ~ dry bulb value; wb ~ wet bulb value

Problem

To determine the size of dehumidifier necessary to maintain the desired controlled space conditions.

Assumptions

1. The door is adequately weather stripped and is of standard construction.
2. Ten workers in the area maintain a moderate pace; each requires ventilating air.
3. The interior of the control space is constructed with two coats of vapor barrier paint.
4. There are no other openings in and out of the controlled space.
5. All physical cracks are sealed.
6. A vapor barrier is provided in or under the concrete floor.

Space Moisture Loads to be Computed

1. Permeation load
2. Load through the door
3. Population load.

Permeation Load

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

$$V = 60 \times 42 \times 16 = 40,320 \text{ ft.}^3$$

$$C = 14 \text{ (Specific volume of dry air @ } 95^\circ\text{F)}$$

$$\Delta G = 75 \text{ outside design wet bulb of } 75^\circ\text{F gives 121 gr/lb from Table I}$$

Controlled space requirement of 75°Fdb , 35% rh yields 46 grains per pound from standard Psychrometric chart. Therefore, $121 - 46 = 75 \text{ grs/lb.}$

$$F_1 = 1.94 \text{ From Table II – Factor for moisture difference of 75 gr/lb - interpolated}$$

$$F_2 = .5 \text{ from Table III}$$

$$F_3 = 1.0 \text{ From Table IV – Factor for 8" masonry}$$

$$F_4 = .75 \text{ From Table IV – Factor for 2 coats paint}$$

$$\frac{40,320}{14} \times 75 \times 1.94 \times .5 \times 1.0 \times .75 = 157,140 \text{ grs/hr}$$

Door Load

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

$$O_{hr} = 6$$

$$A = 6 \times 7 = 42 \text{ sq ft}$$

$$C = 7$$

$$\Delta G = 75$$

$$F_1 = 1.94$$

$$6 \times \frac{42}{7} \times 75 \times 1.94 = 5,238 \text{ gr/hr}$$

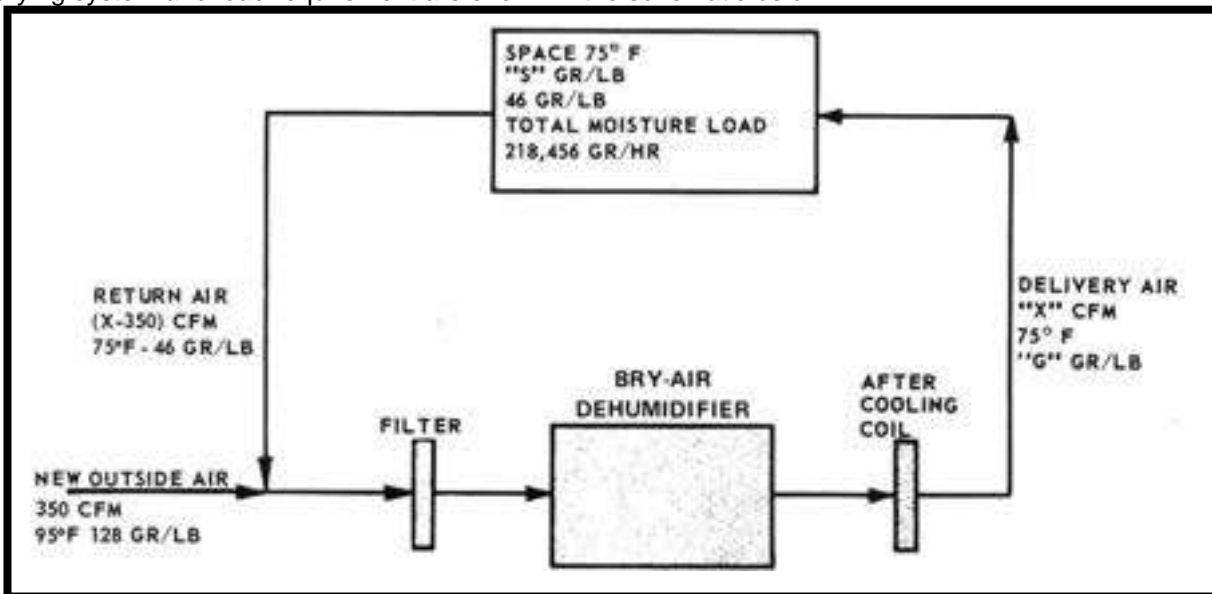
Population Load

At a db of 75° F and working at a moderate rate, a person will expel 2,540 grains each hour. Therefore, ten people will add: $10 \times 2,540 = 25,400$ grains each hour

Total Load

157,140 grs/hr	Permeation
5,238 grs/hr	Through door
<u>25,400 grs/hr</u>	<u>Population load</u>
187,778 grs/hr	Total

The drying system and load requirement are shown in the schematic below:



Note that 350 cubic feet per minute (cfm) outside air is based on a requirement of 30 cfm for each of 10 workers is introduced at the dehumidifier. The effect of this air on the ultimate de-humidifier size will be handled below.

Proceed with the following calculation:

$$X = C \times \frac{\text{gr/hr}}{60} \div (S - G)$$

Where:

- X = cfm Delivery air rate from dryer to space
- gr/hr = total grains per hour in space
- C = 14 = constant
- S = 46 = Grs/lb moisture requirement of controlled space. In the absence of a ventilation requirement this would be the inlet condition at dryer.
- G = Grs/lb of air leaving dryer. Enter curve at 46 grain "Inlet moisture condition." Intersect 75° Inlet air temp curve at 14 gr/lb

$$14 \times \frac{187,778}{60} \div (46 - 14) = 1369 \text{ cfm}$$

From the above calculation the space moisture load is 187,778 gr/min. 1369 cfm air at 14 grs/ lb will maintain the space design conditions.

At this stage in the procedure, it is necessary to resort to the method of approximation to select the correct dryer.

In addition to handling the space load the dryer must handle the moisture load contributed by the 350 cfm outside air requirement. So use a 2000 cfm Bry-Air Dryer (MVB-20-C).

If the dryer has a delivery rate of 2000 cfm, and if 350 cfm of outside air is to be introduced, there remains 1650 cfm of air from the conditioned space. Tabulate this air mixture

350 cfm × 121 gr/lb =	42,350
1650 cfm × 46 gr/lb =	75,900
2000 cfm	118,250

Then $\frac{118,250}{2000} = 59.1 \text{ grs/lb}$

Referencing the Typical Performance Curves Chart 1, shows that air entering the dryer at 59.1 grs/lb would leave the dryer at approximately 23 grs/lb. (NOTE: Interpolate between the 75° and 85° curves since the air is a mixture of 75° and 95° = 79° F.)

$$\text{Total moisture pick up } X = C \frac{X}{C} \times (S - G) \times 60 - \text{Total Moisture Pickup}$$

$$\frac{2000}{14} \times (46 - 23) \times 60 = 197,123 \text{ grs/hr total removal capacity}$$

The following work sheet is a demonstration of what the calculations will look like.

In the above calculations, moisture gain or air leakage in the process ductwork was not considered. If, however, the process and return ductwork did contribute to the moisture load, the total duct volume would be an additional space. Then the permeation calculation in Part Four would be used: V = duct volume; C = 14; F, from Table II, with moisture difference ~G measured from inside process air duct to surround ambient; F3 for tight, good commercial ductwork = 0.6. Add the resultant moisture gain to the room total load. A nominal allowance for process air lost due to duct leakage = 5 percent.

Recommendation

Selecting a VFB-24- at 2000 CFM is the best choice for the hard candy manufacturing example. While it may seem to be an oversized selection, consider that all desiccants in all manufacturers' desiccant dryers will age, will possibly become physically and chemically contaminated with dirt, dust, or chemicals, and will gradually lose their effectiveness. Fortunately, with the VFB-24, higher levels of moisture in the leaving air-up to 24 grs/lb dry air-could be tolerated prior to a desiccant change. So what appears to be an oversized selection would actually allow much longer use of a desiccant charge and provide the economies of longer use.

Bry-Air Dehumidifier Calculation Sheet
Project: Example I – Production of Hard Candy

Conditions					Room Size							
Surrounding Design	95 FDB	75 FWB	121gr		60 L	42 W	16 H	= 40,320				
	75 FDB	0 FWB	46gr	35 RH		40,320 FT ³		= 672				
	20 Δ T		75 Δ gr			60						
Permeation									GR/HR			
Volume	$\frac{40,320 \text{ FT}^3}{14}$	×	$\frac{75}{(\Delta \text{ gr})}$	×	$\frac{1.94}{(F_1)}$	×	$\frac{0.5}{(F_2)}$	×	$\frac{1}{(F_3)}$	×	$\frac{0.75}{(F_4)}$	= 157,140
Door Load												
Openings/hr	6	×	Area	$\frac{42 \text{ FT}^2}{7}$	×	$\frac{75}{(\Delta \text{ gr})}$	×	$\frac{1.94}{(F_1)}$				= 157,140
Openings/hr	0	×	Area	$\frac{0 \text{ FT}^2}{7}$	×	$\frac{75}{(\Delta \text{ gr})}$	×	$\frac{1.94}{(F_1)}$				= 0
Fixed Opening												
			0 (area)	×	$\frac{300}{14}$	×	$\frac{1}{(\text{dep})}$	×	$\frac{75}{(\Delta \text{ gr})}$	×	$\frac{1.94}{(F_1)}$	= 0
People Load												
			10 (# people)	×	$\frac{2540}{(F_5)}$							= 25,400
Product Load												
			0 gr/hr removed									= 0
Product Load												
			0 gr/hr added									= 0
TOTAL ROOM LOAD = 187,778												
CFM Required												
14	×		$\frac{187,778}{60}$	÷		46 - 14						= 1369CFM
Make-Up Air												
			$\frac{350}{14}$	×		$\frac{75}{(\Delta \text{ gr})}$			×	60		= 112,500
TOTAL GR/HR = 300,278												
1,650	CFM RETURN AIR	@	75 FDB			46 GR						
350	CFM MAKE-UP AIR	@	95 FDB			121 GR						
= DEHUMIDIFIER INLET CONDITION:												
									CFM		2,000	
									DB TEMP.		79	
									GR/LB		59	
Dehumidifier Sizing												
14	×		$\frac{300,278}{60}$	÷		59 - 23						= 1,946 CFM Required
Proof												
			$\frac{2000}{14}$	×		(46 – 23)			×	60		= 197,143 System Capability
						DEHUMIDIFER REQUIRED				VFB-24		
						PROCESS OUTLET TEMP.				130°F		

Example II: Standby Warehouse

Moisture damage in a standby or storage warehouse can be avoided by surrounding the machinery, equipment, or material with dry air.

Physical Facts

1. Area to be conditioned - 210' x 176' X 45' = 1,663,200 cubic feet
2. Outside design condition - 95° F db; 77 F wb
3. Controlled space requirement* - 85°F db; 40 percent rh
4. No physical openings nor appreciable amount of door openings or closings specified
5. No people working in the area
6. Construction - 8" masonry.
7. See Appendix 5 [LINK TO APP5](#)

Problem

To determine the size of the dehumidifier required to maintain standby conditions.

Assumptions

1. All physical cracks are sealed and the floor properly vapor-proofed.
2. If the room is completely vapor-proofed, use Table 4 on page 8.
3. Two coats of vapor barrier paint has been applied externally for metal clad construction.*

* External application is recommended because:

Outside walls are usually easier to access than inside walls for paint application.

Coating the outside walls discourages water permeation into the wall and thus minimizes water accumulation in the wall structure itself.

Space Moisture Loads to be Computed

1. Permeation load
2. Moisture load.

The Permeation Load is the only moisture load involved in this example.

$$\frac{V}{C} \times \Delta G \times F_1 \times F_2 \times F_3 \times F_4 = \text{grs/hr}$$

Where:

$$V = 210 \times 176 \times 45 = 1,663,200 \text{ ft.}^3$$

$$C = 14 = \text{constant}$$

$$\Delta G = 58 \text{ grs/lb. Outside design web bulb of } 77^\circ\text{F gives } 130 \text{ grs/lb from Table I (LINK)}$$

Controlled space requirement of 85°F db, 40% rh yields 72

Grs/lb from a standard Psychrometric chart. Therefore, $130 - 72 = 58$.

$$F_1 = 1.54 \text{ From Table II – Factor for moisture difference of } 63 \text{ gr/lb}$$

$$F_2 = 0.24 \text{ from Table III – extrapolated as straight line for a volume of } 1,663,200 \text{ cubic feet.}$$

$$F_3 = 1.0 \text{ From Table IV – Factor for } 8" \text{ masonry}$$

$$F_4 = .75 \text{ From Table IV – Factor for 2 coats paint}$$

$$\frac{1,663,200}{14} \times 58 \times 1.54 \times 0.24 \times 1.0 \times .75 = 1,910,019 \text{ grs/hr}$$

Refer to schematic blow which shows the load requirements and drying system.

$$X = C \times \frac{\text{gr/hr}}{60} \div (S - G)$$

Where:

X = cfm Delivery air rate from dryer to space

C = 14 = constant

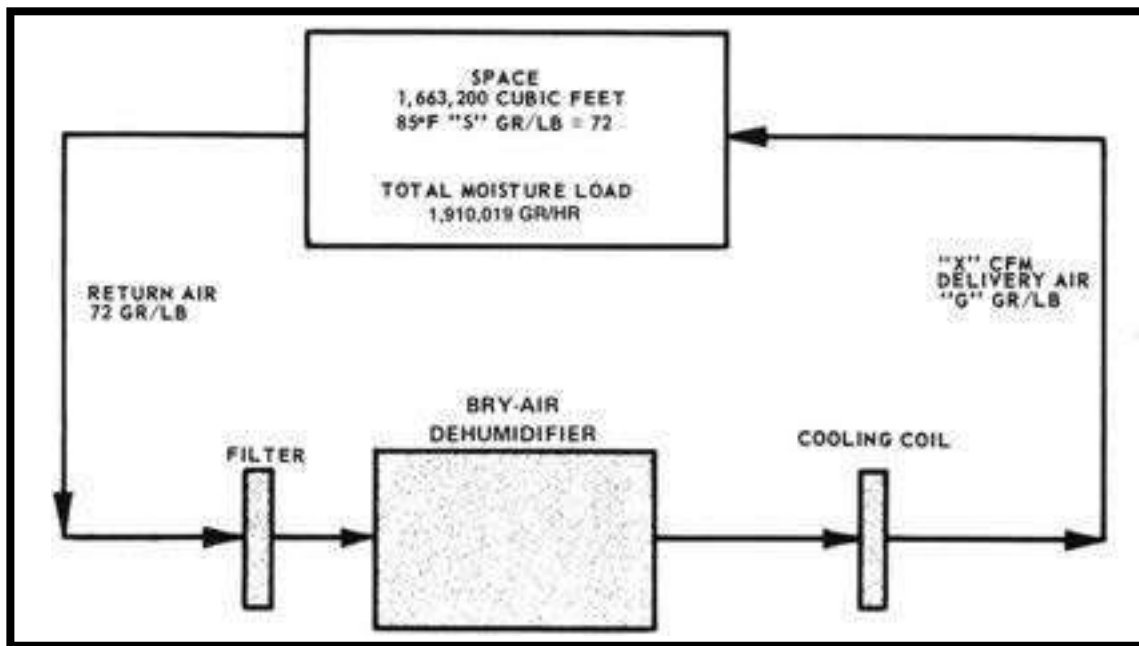
S = 72 = grs/lb moisture requirement of controlled space.

G = grs/lb of air leaving dryer.

Enter curve at 72° "Inlet Moisture Condition". Interpolate "Inlet Air Temperature Curve" between 75° and 95° and find "leaving Moisture" at 33 grs/lb.

$$X = 14 \times \frac{1,910,019}{60} \div (72 - 33)$$

$$X = 11,427 \text{ cfm}$$



Therefore, 11,427 cfm of air (33 gr/lb) from the dehumidifier is needed to maintain a grain level of 72 gr/lb.

In a building of this size and shape, air distribution ducts are practical for effectively spreading the air so it can return to a common point and re-enter the dehumidifier.

Recommendation

Use one Bry-Air VFB-150 Dehumidifier at 12,500 CFM in this standby warehouse example with a fan sized to handle the necessary static pressure of the duct system.

Bry-Air Dehumidifier Calculation Sheet
Project: Example II – Standby Warehouse

Conditions				Room Size									
Surrounding Design	95 FDB	77 FWB	130 gr	210 L	176 W	45 H	= 1,663,200						
	85 FDB	0 FWB	72 gr 40 RH	1,663,200 FT ³			= 27,720						
	10 Δ T		58 Δ gr	60									
Permeation				GR/HR									
Volume	1,663,200 FT ³	×	58 (Δ gr)	×	1.54 (F ₁)	×	0.24 (F ₂)	×	1 (F ₃)	×	0.75 (F ₄)	= 1,910,019	
	14												
Door Load													
Openings/hr	0	×	Area	0 FT ²	×	58 (Δ gr)	×	1.54 (F ₁)					= 0
				7									
Openings/hr	0	×	Area	0 FT ²	×	58 (Δ gr)	×	1.54 (F ₁)					= 0
				7									
Fixed Opening													
			0 (area)	×	300 14	×	1 (dep)	×	58 (Δ gr)	×	1.54 (F ₁)	= 0	
People Load													
			0 (# people)	×	2540 (F ₅)								= 0
Product Load													
	0 gr/hr removed											= 0	
Product Load													
	0 gr/hr added											= 0	
TOTAL ROOM LOAD												= 1,910,019	
CFM Required													
14	×	1,910,639 60	÷	72 - 33							= 11,427CFM		
Make-Up Air													
		0 14	×	58 (Δ gr)	×	60							= 0
TOTAL GR/HR												= 1,910,019	
12,500 CFM RETURN AIR @ 85 FDB 72 GR													
0 CFM MAKE-UP AIR @ 95 FDB 130 GR													
= DEHUMIDIFIER INLET CONDITION:													
CFM DB TEMP. GR/LB												12,500 85 72	
Dehumidifier Sizing													
14	×	1,910,019 60	÷	72 - 33							= 11,427 CFM Required		
Proof													
		12,500 14	×	(72 - 23)	×	60							= 2,089,286 System Capability
DEHUMIDIFER REQUIRED												VFB-150	
PROCESS OUTLET TEMP.												138°F	

Example III: Product Drying

Here we have a room used to remove water vapor from such products as cattle feed mixes, nylon or rayon cord for tires, raw plastic material, granular chemicals, raw paper stock, cardboard stock for coatings, or other similar products.

In this example, the room is used for drying cattle feed mixes, which are contained on drying carts that stand in the room until the specified level of dryness is attained.

Space condition requirements and product movement rate are determined by the manufacturer.

Physical Facts

1. Drying room size - 40' x 65' x 16'
2. Outside design condition - 93° F db; 73° F wb
3. Controlled space requirement - 95° F; 15 percent rh (36 gr/lb)
4. One double door: (a) 6' x 7' (b) Opens at 2/hr
5. There are no other openings.
6. There are no workers in room except to bring mix in and out
7. Product movement rate -1500 lb/hr (i.e., carts with trays of mix are moved into the drying
8. room at the rate of 1500 lb/hr)
9. Product enters room at 8 percent moisture and leaves at 4 percent moisture. 9. Drying room wall construction - 8" masonry.
10. 350 cfm outside air required by manufacturer.

Problem

To determine the size of the dehumidifier.

Assumptions

1. All physical cracks are sealed.
2. The double door is weather stripped.
3. Two coats of vapor barrier paint have been applied to the wall and ceiling construction of the drying room; the floor is suitably protected against vapor permeation.

Moisture Loads to be Computed

1. Product load
2. Permeation load
3. Door load.

Product Load

Since the product will lose 4 percent moisture (by weight) and there are 1500 pounds of product each hour:

$$1500 \text{ lb./hr} \times (8\% - 4\%) = 60 \text{ lb./hr water removal}$$

Since one pound of water equals 7000 grains, then:

$$60 \times 7000 = 420,000 \text{ gr/hr product load.}$$

Note that the time needed to reduce the material to a 4 percent moisture level would have to be given or experimentally determined. These data would determine the amount of material to process and the size of the drying chamber needed.

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

Where:

$$V = 40 \times 65 \times 16 = 41,600 \text{ ft.}^3$$

$$C = 14 = \text{constant}$$

$$\Delta G = 77 \text{ Outside design wet bulb of } 73^\circ\text{F gives } 113 \text{ grs/lb. Drying room space Requirement of } 95^\circ\text{F, } 15\% \text{ rh yields } 36 \text{ Grs/lb from a standard Psychrometric chart.}$$

$$F_1 = 1.99 \text{ from Table II – Factor for moisture difference of } 84 \text{ grains.}$$

$$F_2 = 0.50 \text{ from Table III – Permeation factor}$$

$$F_3 = 1.0 \text{ from Table IV – Factor for } 8" \text{ masonry}$$

$$F_4 = 0.75 \text{ from Table IV – Factor for } 2 \text{ coats paint}$$

$$\frac{41,600}{14} \times 77 \times 1.99 \times .50 \times 1.0 \times .75 = 170,742 \text{ grs/hr}$$

Door Load

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

$$O_{hr} = 1$$

$$A = 6 \times 7 = 42 \text{ sq ft}$$

$$C = 7 \text{ (constant)}$$

$$\Delta G = 77 \text{ grs/lb.}$$

$$F_1 = 1.99 \text{ from Table II – Factor for moisture difference of } 84 \text{ grains.}$$

$$2 \times \frac{42}{7} \times 77 \times 1.99 = 1,839 \text{ gr/hr}$$

Total Moisture Load

$$420,000 \text{ gr/hr} \quad \text{Product Load}$$

$$170,742 \text{ gr/hr} \quad \text{Permeation Load}$$

$$1,839 \text{ gr/hr} \quad \text{Door Load}$$

$$592,581 \text{ gr/hr} \quad \text{Total Moisture Load}$$

The 350 cfm outside air requirement will be considered at a later stage in the calculation.

Proceed with calculation as follows:

$$X = C \times \frac{\text{gr/hr}}{60} \div (S - G)$$

Where:

$$X = \text{cfm – air rate from dryer}$$

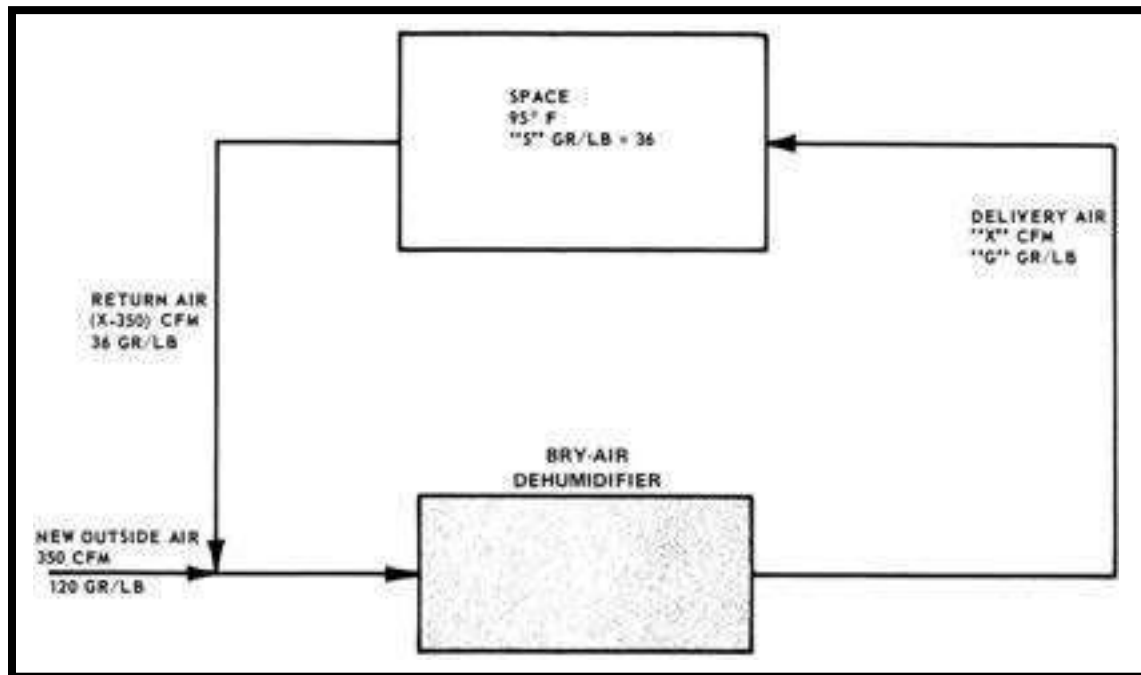
$$C = 14 = \text{constant}$$

$$S = 36 = \text{grs/lb drying room controlled space requirement. In the absence of an outside air requirement this would also be the inlet condition at dryer.}$$

$$G = 15 \text{ grs/lb – equals condition of air leaving dryer. Enter curve at } 36 - \text{intersect } 95^\circ\text{F curve at } 15 \text{ gr/lb.}$$

$$X = 14 \times \frac{592,321}{60} \div (36 - 15)$$

$$X = 6584 \text{ cfm}$$



Recommendation

The Bry-Air VFB-75 Dehumidifier, rated at 7500 cfm, should be adequate. However, the first step should be to determine if this Dehumidifier has enough capacity to handle the 350 cfm outside air in addition to the moisture load in the drying room.

If the dryer has a delivery rate of 7500 cfm and 350 cfm of outside air is to be introduced, there remains 7150 cfm from the conditioned space. Tabulate this air mixture as follows:

$$\begin{array}{rcl} 350 \text{ cfm} \times 113 \text{ gr/lb.} & = & 39,550 \\ \frac{7150 \text{ cfm} \times 36 \text{ gr/lb.}}{7500} & = & \frac{257,400}{296,950} \end{array}$$

$$\frac{296,950}{7500} = 39.6$$

Reference to Chart 1, Appendix 4, shows that air entering the dryer at 39.5 gr/lb. would leave at 17 gr/lb.

$$\frac{7500}{14} \times (36 - 17) \times 60 = 610,714 \text{ gr/hr}$$

The computed moisture load is 592,581 gr/hr. Therefore, the VFB-75 is adequate to handle the moisture load.

Bry-Air Dehumidifier Calculation Sheet

Project: Example III – Product Drying

Conditions				Room Size			
Surrounding Design	93 FDB	73 FWB	113 gr	65 L	40 W	16 H	= 41,600
	95 FDB	0 FWB	36 gr 15 RH	41,600 FT ³			= 693
	-2 Δ T		77 Δ gr	60			
Permeation							GR/HR
Volume	$\frac{41,600 \text{ FT}^3}{14}$	x	$\frac{77}{(\Delta \text{ gr})}$	x	$\frac{1.99}{(F_1)}$	x	$\frac{0.5}{(F_2)}$
				x	$\frac{1}{(F_3)}$	x	$\frac{0.75}{(F_4)}$
							= 170,742
Door Load							
Openings/hr	2 x Area	$\frac{42 \text{ FT}^2}{7}$	x	$\frac{75}{(\Delta \text{ gr})}$	x	$\frac{1.99}{(F_1)}$	= 1,839
Openings/hr	0 x Area	$\frac{0 \text{ FT}^2}{7}$	x	$\frac{75}{(\Delta \text{ gr})}$	x	$\frac{1.99}{(F_1)}$	= 0
Fixed Opening							
		$\frac{0}{(\text{area})}$	x	$\frac{300}{14}$	x	$\frac{1}{(\text{dep})}$	x
					x	$\frac{75}{(\Delta \text{ gr})}$	x
						$\frac{1.94}{(F_1)}$	= 0
People Load							
		$\frac{0}{(\# \text{ people})}$	x	$\frac{2540}{(F_5)}$			
					= 0		
Product Load							
		0 gr/hr removed					= 420,000
Product Load							
		0 gr/hr added					= 0
TOTAL ROOM LOAD							= 592,581
CFM Required							
14	x	$\frac{592,581}{60}$	÷	36 - 15			= 6,584 CFM
Make-Up Air							
		$\frac{350}{14}$	x	$\frac{77}{(\Delta \text{ gr})}$	x	60	= 115,500
TOTAL GR/HR							= 708,081
7,150	CFM RETURN AIR	@	95 FDB	36 GR			
350	CFM MAKE-UP AIR	@	93 FDB	113 GR			
= DEHUMIDIFIER INLET CONDITION:						CFM	7,5000
						DB TEMP.	95
						GR/LB	40
Dehumidifier Sizing							
14	x	$\frac{300,278}{60}$	÷	40 - 17			= 7,183
							CFM Required
Proof							
		$\frac{7,500}{14}$	x	(36 - 17)			x
						60	= 610,714
						System	
						Capability	
DEHUMIDIFER REQUIRED						VFB-75	
PROCESS OUTLET TEMP.						135°F	

Example IV: Controlled Humidity and Temperature Areas

Many air conditioned manufacturing areas often have a required air flow to handle a sensible load in that space. This air quantity requirement and the accompanying dehumidifier size are usually greater than those needed to handle a latent load. By designing a system for the sensible load situation and then determining the appropriate dehumidifier to handle the moisture load, the desired conditions for the space can be maintained.

Physical Facts

1. Area to be conditioned - 62.5' x 55' x 14'
2. Outside design conditions- 95°F db; 77°F wb
3. Controlled space requirement - 55°F db; 30 percent rh; 20 gr/lb.
4. Doors - 1 (6' X 8'), 6 openings/hr; 1 (3' x 7'), 40 openings/hr
5. Other (fixed) openings - 2.8 sq ft, w/tunnel 10' deep
6. Number of people working in area - 10
7. Air required for sensible temperature control - 24,715 cfm, 42°F
8. Construction - Block walls; drywall ceiling with vapor proofing; concrete floor on grade
9. Make-up air required - 2400 cfm
10. Air available for make-up - 50°F db/49°F wb; 50 gr/lb.

Problem

To determine the size dehumidifier needed in a controlled humidity and temperature area.

Moisture Load to be Computed

1. Permeation
2. Load through doors
3. Load through fixed openings
4. Population load.

Permeation Load

$$\frac{V}{C} \times \Delta G \times F_1 \times F_2 \times F_3 \times F_4 = \text{grs/hr}$$

Where:

$$V = 62.5 \times 55 \times 14 = 48,125 \text{ ft.}^3$$

$$C = 14 = \text{constant}$$

$$\Delta G = 110 \text{ (Ambient 130 gr/lb - room 20 gr/lb)}$$

$$F_1 = 2.76 \text{ from Table II - Factor for moisture difference of 110 gr/lb.}$$

$$F_2 = 0.48 \text{ from Table III - for 48,125 cu. Ft.}$$

$$F_3 = 1.0 \text{ from Table IV - Frame masonry \& frame construction}$$

$$F_4 = .9 \text{ for vapor proof paint on walls \& ceilings, untreated concrete floor}$$

$$\frac{48,125}{60} \times 110 \times 2.76 \times .48 \times 1.0 \times .9 = 450,846 \text{ gr/hr}$$

Door Load

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

$$O_{hr} = 6 \text{ openings}$$

$$A = 6 \times 8 = 48 \text{ sq ft}$$

$$C = 7 = \text{constant}$$

$$\Delta G = 110 \text{ grs/lb.}$$

$$F_1 = 2.76 \text{ from Table II - Factor for moisture difference of 84 grains.}$$

$$6 \times \frac{48}{7} \times 110 \times 2.76 = 12,491 \text{ gr/hr}$$

O_{hr} = 4 openings

A = 3 × 7 = 21 sq ft

C = 7 = constant

ΔG = 110 grs/lb.

F₁ = 2.76 from Table II – Factor for moisture difference of 84 grains.

$$4 \times \frac{21}{7} \times 110 \times 2.76 = 3,643 \text{ gr/hr}$$

Fixed Openings

$$\frac{A \times 300}{C \times D} \times \Delta G \times F_1 = \text{grs/hr}$$

A = area, 2.8 sq. ft.

300 = Constant (vel. of vapor)

C = 14 Constant

D = Depth of tunnels

ΔG = 110 gr/lb

F₁ = 2.76

$$\frac{2.8 \times 300}{14 \times 10} \times 110 \times 2.76 = 1,822 \text{ grs/hr}$$

Population Load

At a db of 55° and working at a "light physical exertion" - 1100 gr/hr/person

10 people × 1100 gr = 11,000 gr/hr

Total Room Moisture Load

450,846 gr/hr Permeation

12,491 gr/hr Door Load

3,643 gr/hr Door Load

1,822 gr/hr Fixed Opening Load

11,000 gr/hr Population Load

479,802 gr/hr Total Room Load

The total room latent moisture load is 479,802 gr/hr, which is added into the calculation below to find the entering grain condition needed for the space.

$$\frac{\text{Total cfm}}{14} \times (S - G) \times 60 = \text{Room load (gr /hr)}$$

Total cfm = 24,715 cfm

14 = constant

S = 20 gr/lb. (condition of controlled space)

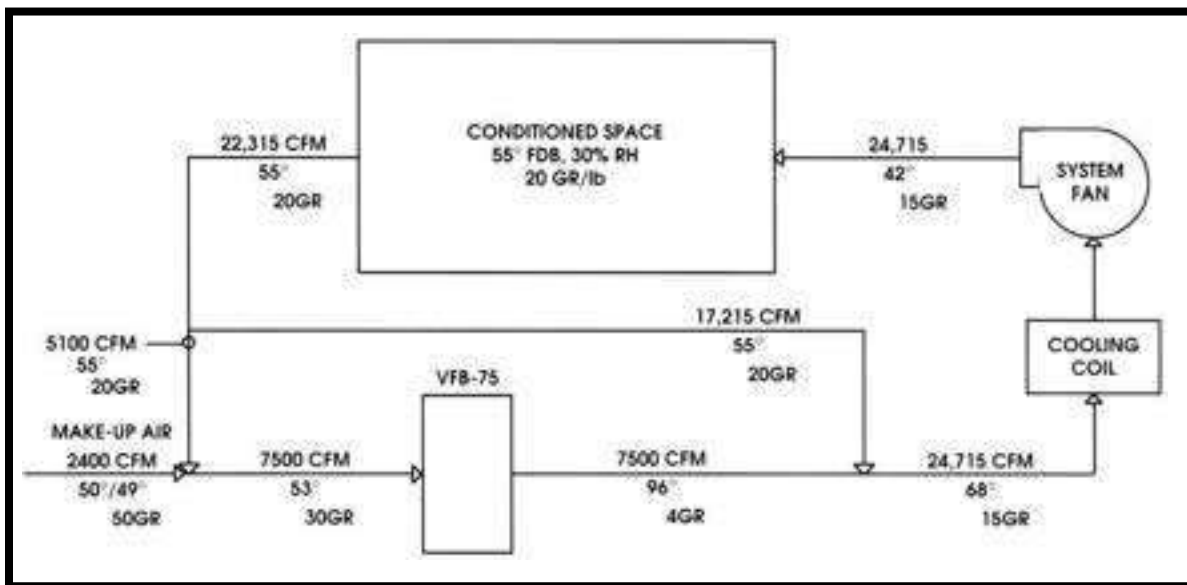
G = Unknown grain level needed entering space

60 = min/hr

$$\frac{24,715}{14} \times (20 - G) \times 60 = 479,802$$

G = 15.4 gr/lb.

Thus the air to the room must be 15.4 gr/lb. and the air mixture (return from the room plus the dehumidifier discharge) entering the main system fan should be 15 gr/lb. to allow for possible leakage into the system duct work. Here one must resort to trial and error techniques to select the dehumidifier size.



$$\frac{\text{cfm}}{14} \times (S - G) \times 60 = X$$

cfm = 7500 cfm - dehumidifier capacity (trial)
 14 = constant
 S = 20 gr/lb. condition in the controlled space
 G = 4 gr/lb. air leaving dehumidifier (LINK) with entering air 53°F, 30 gr/lb.

$$\frac{7500}{14} \times (20 - 4) \times 60 = 514,285 \text{ gr/hr}$$

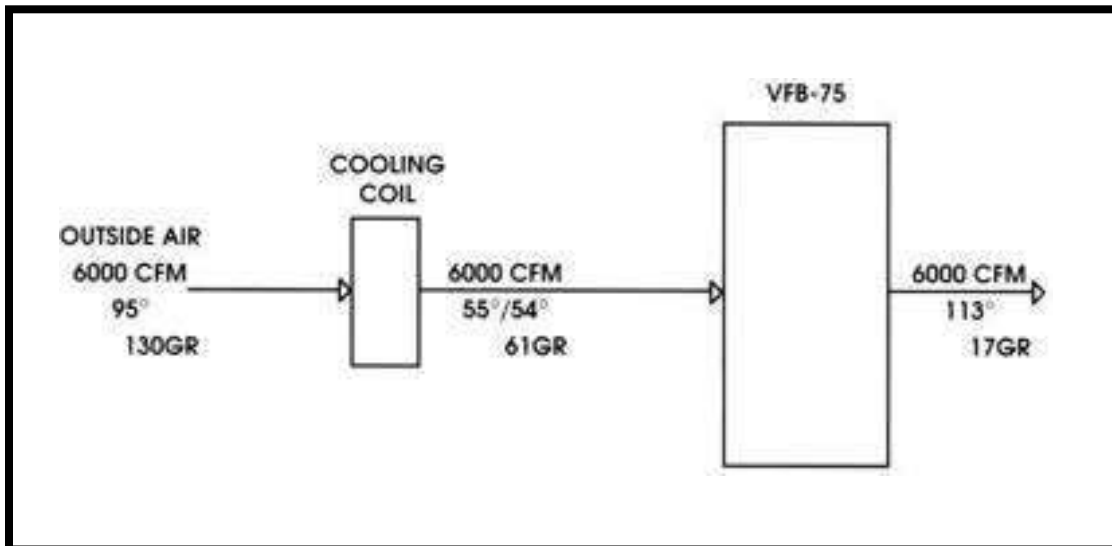
Note that the make-up air of 2400 cfm must mix with 5100 cfm of return air before entering the dehumidifier.

Recommendation

The VFB-75 Dehumidifier will satisfy the room load conditions when mixed with the remaining 17,215 cfm of return air and delivered into the conditioned space.

Project: Example IV – Controlled Humidity and Temperature Areas

Conditions				Room Size			
Surrounding Design	95 FDB	77 FWB	130 gr	62.5 L	55 W	14 H	= 48,125
	55 FDB	0 FWB	20 gr 30 RH	48,125 FT ³			= 802
	40 Δ T		110 Δ gr	60			
Permeation							GR/HR
Volume	$\frac{48,125 \text{ FT}^3}{14}$	x	$\frac{110}{(\Delta \text{ gr})}$	x	$\frac{2.76}{(F_1)}$	x	$\frac{0.48}{(F_2)}$ x $\frac{1}{(F_3)}$ x $\frac{0.9}{(F_4)}$ = 450,846
Door Load							
Openings/hr	6 x Area	$\frac{48 \text{ FT}^2}{7}$	x	$\frac{110}{(\Delta \text{ gr})}$	x	$\frac{2.76}{(F_1)}$	= 12,491
Openings/hr	4 x Area	$\frac{21 \text{ FT}^2}{7}$	x	$\frac{110}{(\Delta \text{ gr})}$	x	$\frac{2.76}{(F_1)}$	= 3,643
Fixed Opening							
		$\frac{2.8}{(\text{area})}$	x	$\frac{300}{14}$	x	$\frac{10}{(\text{dep})}$ x $\frac{110}{(\Delta \text{ gr})}$ x $\frac{1.94}{(F_1)}$	= 1,822
People Load							
		$\frac{10}{(\# \text{ people})}$	x	$\frac{1,100}{(F_5)}$			= 11,000
Product Load							
		0 gr/hr removed					= 0
Product Load							
		0 gr/hr added					= 0
TOTAL ROOM LOAD							= 479,802
CFM Required							
14	x	$\frac{479,802}{60}$	÷	20 - 2			= 6,220 CFM
Make-Up Air							
		$\frac{2,400}{14}$	x	$\frac{30}{(\Delta \text{ gr})}$	x	60	= 308,571
TOTAL GR/HR							= 788,373
5,100	CFM RETURN AIR	@	55 FDB	20 GR			
2,400	CFM MAKE-UP AIR	@	50 FDB	50 GR			
= DEHUMIDIFIER INLET CONDITION:						CFM	7,500
						DB TEMP.	95
						GR/LB	40
Dehumidifier Sizing							
14	x	$\frac{788,373}{60}$	÷	30 - 4			= 7,075 CFM Required
Proof							
		$\frac{7,500}{14}$	x	(20 - 4)		x 60	= 514,285 System Capability
DEHUMIDIFER REQUIRED						VFB-75	
PROCESS OUTLET TEMP.						96°F	



Example V: Production of Dry Air for a Specific Purpose

Many applications require a specific quantity of outside air to be delivered at a given moisture content and temperature. This requirement may be a need to make up air exhausted from a space or to supply air for a process such as a drying oven.

Physical Facts

1. Maximum allowable moisture content - 17 gr/lb of dry air
2. Maximum allowable temperature - 115°F
3. Quantity of air required - 6,000 cfm
4. Maximum condition of outside air - 95°F, 130 gr/lb

From the Typical Performance Curves chart it is obvious that 130 grain air cannot be reduced to 17 grains in a single pass through a dehumidifier, without other conditioning. Examination of Chart 1 shows that to produce 17 grains air leaving the dehumidifier, the inlet condition should be 64 grains or less at 60°F or less.

This is accomplished as shown above by installing a cooling coil upstream of the dehumidifier to reduce the temperature and moisture content of the outside air.

Example VI: Water Treatment Plants

In most water pumping stations, filtration plants, and waste water control plants, control of humidity in the pipe galleries, pump rooms, and control rooms is of prime importance. By reducing the dew-point temperature of the air below the temperature of the piping and walls, sweating and condensation can be eliminated. By circulating warm, dry air through the areas, water accumulation is avoided, maintenance for electrical controls, motors, and instruments is reduced, and paint lasts longer on the pipes, valves, and flanges.

A standard rule-of-thumb is used to approximate this type of application load:

$$\frac{\text{Volume of space to be conditioned}}{25} = \text{CFM dehumidifier}$$

(For each 25,000 cu. ft. of space, supply 1,000 cfm of dry air.)

The use of an after-cooling coil for the dry air discharge from the dehumidifier can be omitted in most installations since the warm, dry air (low rh) will help heat the space during cool or winter conditions. Heat should not build up to an objectionable level because the large piping and wall areas are at the same temperature as the water in the system. Warm air also has the advantage of reducing the rh and increasing the air's capacity to carry away moisture.

Zero Leak System for a Low Humidity Space

In a system where the ductwork and components are outside the controlled space, dry air leaving the system will induce the flow of humid air into the system. If the humid air is not dehumidified, each cfm will induce a load absorbing the capacity provided by 5 to 10 cfm of the dehumidified air. If all air that enters the system must pass through the dehumidifier, the additional load will be reduced by 50 percent or more. Typical air handling units (AHUs) are not built to be vapor tight. Standard sheet metal type ductwork has lapped seams that allow leakage. However, excellent silicone-based sealants are available; for applications requiring very dry spaces, the seams must be welded shut.

Having a "zero leak" condition means that all air leaving the controlled space is under positive pressure (to minimize infiltration), and all the entering air passes through the dehumidifier. The cost of dehumidification is high when moisture levels must be low. In these situations, even small leaks can double operating costs. Since ducts are a once-only expense, attention to ductwork is vital. The other approach to this situation — a higher capacity dehumidifier — means added costs, year after year.

It is unusual to find air handling units constructed for zero leak performance. Leaks are anticipated at removable panels, bearing flanges, drain pans, and through condensate drains with dry traps. Such units require additional sealing and check valves or positive water seals on the condensate lines. Cooling devices, especially the coils and fan, and the filter box need to be handled properly when cleaned, and they, too, must be tight. Obviously, there are many factors that can restrict the zero leak principle.

One way to maximize the chances for a zero leak system is with air treatment equipment and dehumidifiers designed to fit and operate together effectively. Buying directly from the equipment manufacturer and not mixing sources of various equipment components focuses the accountability for moisture tightness.

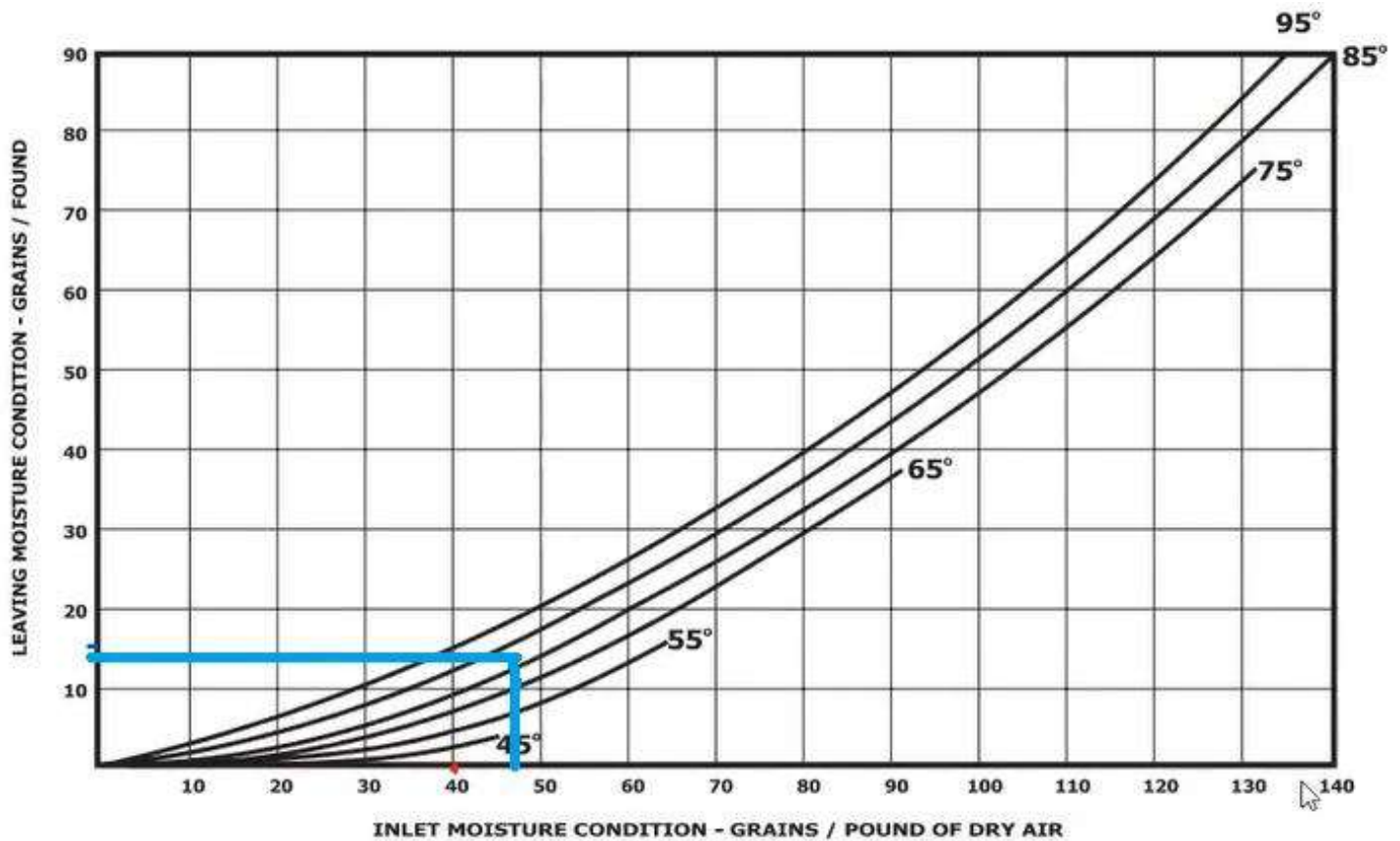
Bry-Air constructs custom dehumidifiers and low dew point AHUs for maximum efficiency. This extra care in design and construction means zero leak performance. Proper operating balance compensates for this situation.

When end users, consulting engineers, or other "specifiers" require a system to be substantially air tight, they mean there is no leakage at any joint.

Assuring zero leak begins in the fabrication and construction stages. We recommend flanged or gasketed connections with welded seams and joints. As a minimum, all seams and joints should be caulked. Removable panels and access doors should be completely enclosed. (Coils will leak where return bends enter tube sheets).

Prior to insulating, the system should be tested and deficiencies corrected. The best method is to use an open flame, if permissible. This requires candles or other sources of flame. In other situations, smoke devices or soap suds could be used.

When all these precautions in fabrication, construction, and testing are complete, the system will perform as designed. Periodic inspection during operation will allow leaks to be located and corrected.



Dry Bulb Temperature	Occupants At Rest	Occupant Doing Light Physical Exertion*	Occupant Doing Heavy Physical Exertion**
F	(gr/hr)	(gr/hr)	(gr/hr)
60°	400	1300	1960
65°	530	1630	2400
70°	670	2060	2920
75°	900	2540	3450
80°	1180	3040	3950
85°	1525	3550	4450
90°	1870	4000	5000

TABLE-2

F1, FACTOR FOR GRAIN DIFFERENCE

Gr/lb difference	F1, Factor
35	1
40	1.12
50	1.35
60	1.59
70	1.82
75	
80	2.06
90	2.29
100	2.53
110	2.76
120	3

TABLE-04

F3, FACTOR FOR CONTRUCTION	F3	F4, FACTORS FOR VAPOR BARRIERS	F4
Masonry or frame construction	1	Laminated, mylar-metallic, or polyethylene film	0.5
Sheet metal, steel welded	0.3	Two-layer edge-sealed moisture paper	0.67
Module panel, caulked and sealed	0.5	Two coats of vapor-proof paint	0.75

TABLE III
F₂ FACTOR FOR SPACE PERMEATION

