10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

Technical Resource Center

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.

Technical Resource Center

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

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 × 42 × 16 = 40,320 ft.^{3}
C = 14 (Specific volume of dry air @ 95°F)
ΔG = 75 outside design wet bulb of 75°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 grs/lb.
F_1 = 1.94 From Table II – Factor for moisture difference of 75 gr/lb - interpolated
F_2 = .5 from Table III
F_3 = 1.0 From Table IV – Factor for 8" masonry
F_4 = .75 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 × 7 = 42 sq ft
C = 7
ΔG = 75
F_1 = 1.94

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

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com
Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

Technical Resource Center

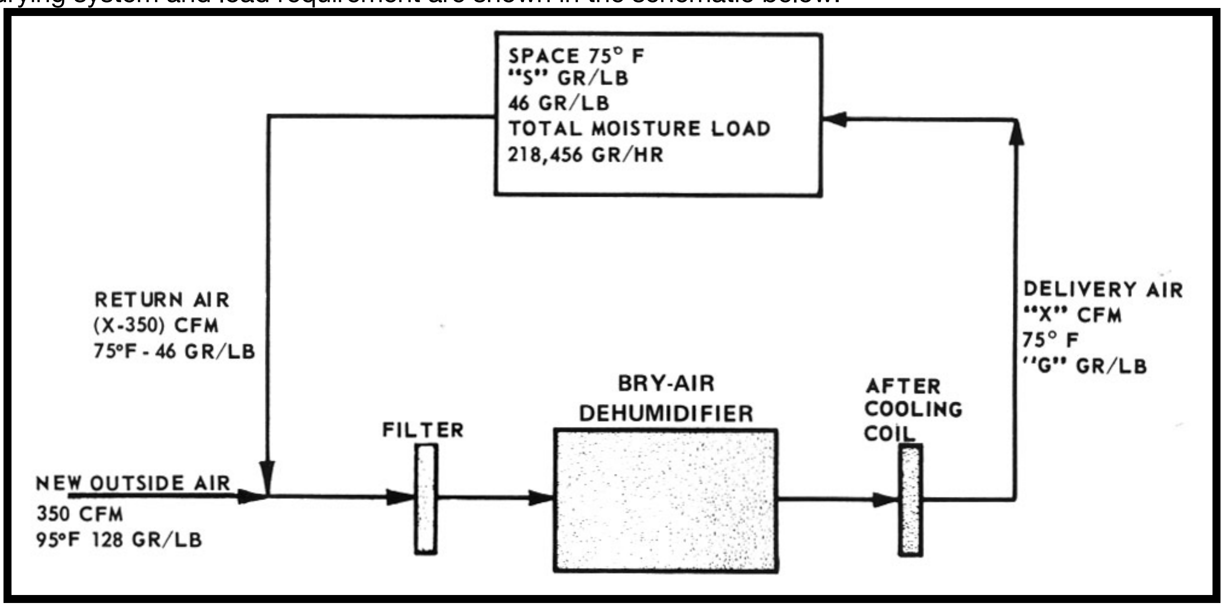
Population Load

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 × 2,540 = 25,400 grains each hour

Total Load

157,140 grs/hr	Permeation
5,238 grs/hr	Through door
25,400 grs/hr	Population load
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:

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

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

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

Bry-Air
EST. 1964
Technical Resource Center

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

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 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.)

Total moisture pick up X = C $\frac{X}{C}$ × (S – G) × 60 – Total Moisture Pickup

$\frac{2000}{14}$ × (46 - 23) × 60 = 197,123 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.

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

Technical Resource Center

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

Conditions					Room Size			
Surrounding	95 FDB	75 FWB	121gr		60 L	42 W	16 H	= 40,320
Design	75 FDB	0 FWB	46gr	35 RH	$\frac{40{,}320\ FT^3}{60}$			= 672
	20 ∆ T		75 ∆ gr					

Permeation GR/HR

Volume $\frac{40{,}320\ FT^3}{14}$ × 75 (∆ gr) × 1.94 (F_1) × 0.5 (F_2) × 1 (F_3) × 0.75 (F_4) = 157,140

Door Load

Openings/hr 6 × Area $\frac{42\ FT^2}{7}$ × 75 (∆ gr) × 1.94 (F_1) = 157,140

Openings/hr 0 × Area $\frac{0\ FT^2}{7}$ × 75 (∆ gr) × 1.94 (F_1) = 0

Fixed Opening

0 (area) × $\frac{300}{14}$ × 1 (dep) × 75 (∆ gr) × 1.94 (F_1) = 0

People Load

10 (# people) × 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

$\frac{350}{14}$ × 75 (∆ 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

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

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 × 176 × 45 = 1,663,200 ft.^{3}
C = 14 = constant
ΔG = 58 grs/lb. Outside design web bulb of 77°F gives 130 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 From Table II – Factor for moisture difference of 63 gr/lb
F_2 = 0.24 from Table III – extrapolated as straight line for a volume of 1,663,200 cubic feet.
F_3 = 1.0 From Table IV – Factor for 8” masonry
F_4 = .75 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.

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

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com
Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

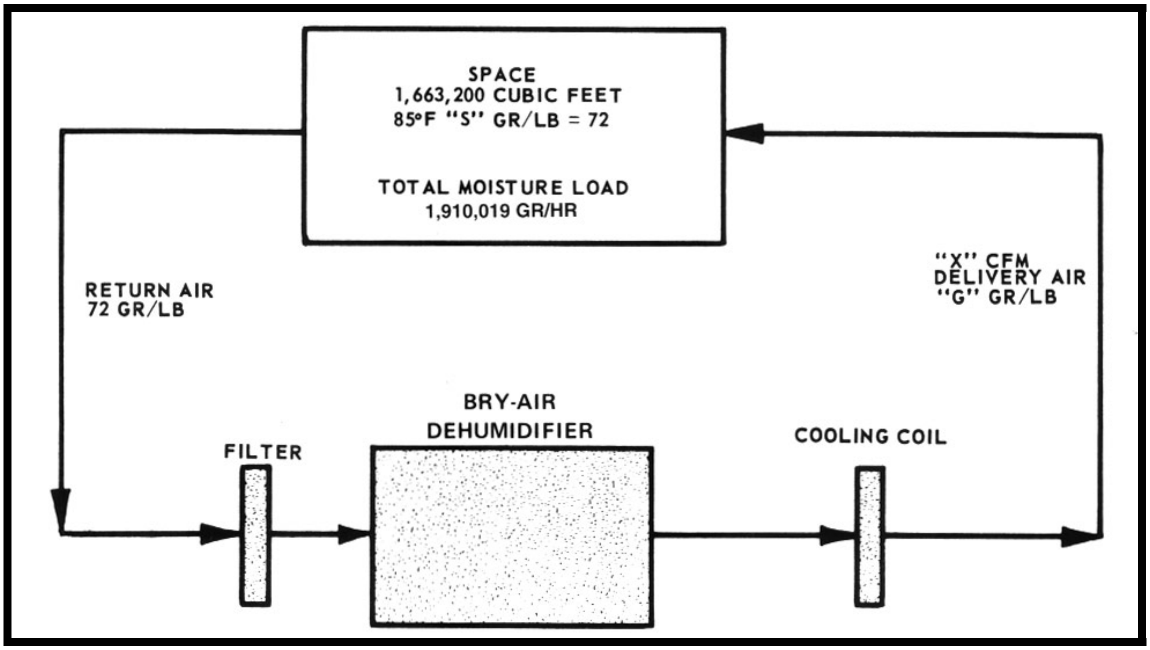
Where:

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 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.

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

Technical Resource Center

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

Conditions					Room Size
Surrounding	95 FDB	77 FWB	130 gr		210 L 176 W 45 H = 1,663,200
Design	85 FDB	0 FWB	72 gr	40 RH	$\frac{1,663,200 \text{ FT}^3}{60}$ = 27,720
	10 Δ T		58 Δ gr		

Permeation GR/HR

Volume $\frac{1,663,200 \text{ FT}^3}{14} \times \frac{58}{(\Delta \text{ gr})} \times \frac{1.54}{(F_1)} \times \frac{0.24}{(F_2)} \times \frac{1}{(F_3)} \times \frac{0.75}{(F_4)}$ = 1,910,019

Door Load

Openings/hr 0 × Area $\frac{0 \text{ FT}^2}{7} \times \frac{58}{(\Delta \text{ gr})} \times \frac{1.54}{(F_1)}$ = 0

Openings/hr 0 × Area $\frac{0 \text{ FT}^2}{7} \times \frac{58}{(\Delta \text{ gr})} \times \frac{1.54}{(F_1)}$ = 0

Fixed Opening

$\frac{0}{(\text{area})} \times \frac{300}{14} \times \frac{1}{(\text{dep})} \times \frac{58}{(\Delta \text{ gr})} \times \frac{1.54}{(F_1)}$ = 0

People Load

$\frac{0}{(\text{\# people})} \times \frac{2540}{(F_5)}$ = 0

Product Load

0 gr/hr removed = 0

Product Load

0 gr/hr added = 0

TOTAL ROOM LOAD = 1,910,019

CFM Required

$14 \times \frac{1,910,639}{60} \div 72 - 33$ = 11,427CFM

Make-Up Air

$\frac{0}{14} \times \frac{58}{(\Delta \text{ gr})} \times 60$ = 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	12,500
DB TEMP.	85
GR/LB	72

Dehumidifier Sizing

$14 \times \frac{1,910,019}{60} \div 72 - 33$ = 11,427 CFM Required

Proof

$\frac{12,500}{14} \times (72 - 23) \times 60$ = 2,089,286 System Capability

DEHUMIDIFER REQUIRED VFB-150

PROCESS OUTLET TEMP. 138°F

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com
Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

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 lb./hr × (8 % - 4%) = 60 lb./hr water removal
Since one pound of water equals 7000 grains, then:
60 × 7000 = 420,000 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.

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com
Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

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

Where:

V = 40 × 65 × 16 = 41,600 $ft.^3$

C = 14 = constant

ΔG = 77 Outside design web bulb of 73°F gives 113 grs/lb. Drying room space Requirement of 95°F,15% rh yields 36 Grs/lb from a standard Psychrometric chart.

F_1 =1.99 from Table II – Factor for moisture difference of 84 grains.

F_2 = 0.50 from Table III – Permeation factor

F_3 = 1.0 from Table IV – Factor for 8" masonry

F_4 = 0.75 from Table IV – Factor for 2 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 × 7 = 42 sq ft

C = 7 (constant)

ΔG = 77 grs/lb.

F_1 = 1.99 from Table II – Factor for moisture difference of 84 grains.

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

Total Moisture Load

420,000 gr/hr	Product Load
170,742 gr/hr	Permeation Load
1,839 gr/hr	Door Load
592,581 gr/hr	Total Moisture Load

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

Proceed with calculation as follows:

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

Where:

X = cfm – air rate from dryer

C = 14 = constant

S = 36 = grs/lb drying room controlled space requirement. In the absence of an outside air requirement this would also be the inlet condition at dyer.

G = 15 grs/lb – equals condition of air leaving dryer. Enter curve at 36 – intersect 95°F curve at 15 gr/lb.

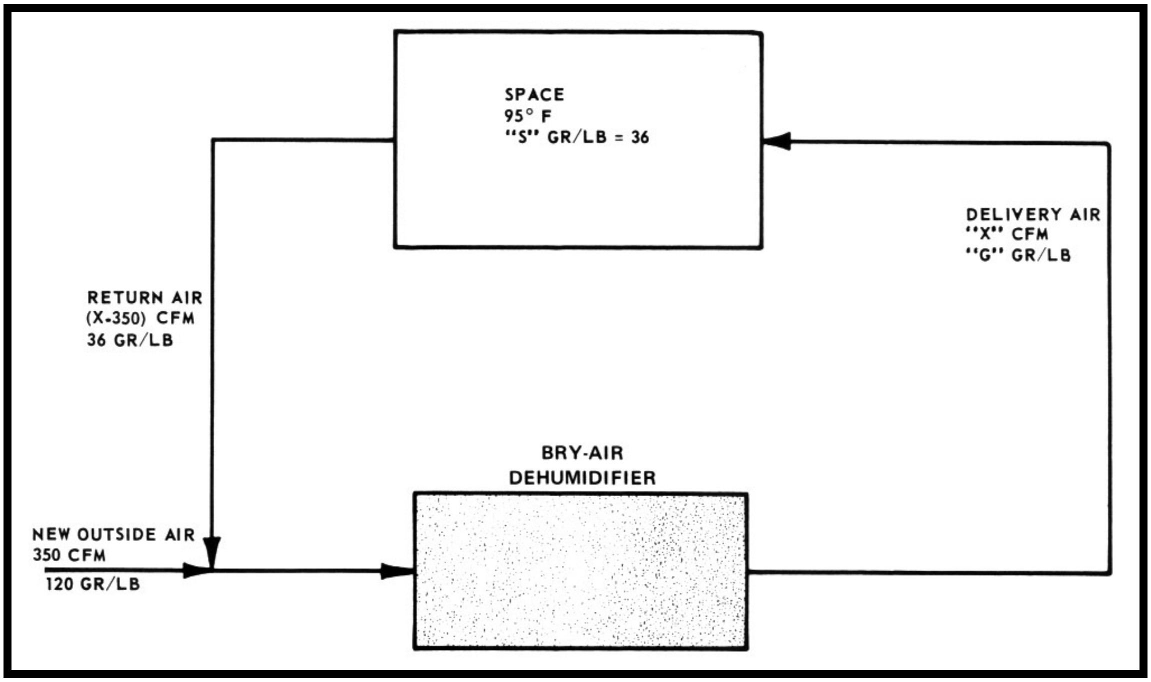
$$X = 14 \times \frac{592{,}321}{60} \div (36 - 15)$$

X = 6584 cfm

Technical Resource Center

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470



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:

350 cfm × 113 gr/lb. =	39,550
7150 cfm × 36 gr/lb. =	257,400
7500	296,950

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

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.

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

Technical Resource Center

Bry-Air Dehumidifier Calculation Sheet
Project: Example III – Product Drying

Conditions					Room Size				
Surrounding	93 FDB	73 FWB	113 gr		65 L	40 W	16 H	= 41,600
Design	95 FDB	0 FWB	36 gr	15 RH	$\frac{41,600\ FT^3}{60}$			= 693
	-2 Δ T		77 Δ gr					

Permeation GR/HR

Volume $\frac{41,600\ FT^3}{14}$ × 77 (Δ gr) × 1.99 (F_1) × 0.5 (F_2) × 1 (F_3) × 0.75 (F_4) = 170,742

Door Load

Openings/hr 2 × Area $\frac{42\ FT^2}{7}$ × 75 (Δ gr) × 1.99 (F_1) = 1,839

Openings/hr 0 × Area $\frac{0\ FT^2}{7}$ × 75 (Δ gr) × 1.99 (F_1) = 0

Fixed Opening

0 (area) × $\frac{300}{14}$ × 1 (dep) × 75 (Δ gr) × 1.94 (F_1) = 0

People Load

0 (# people) × 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 × $\frac{592,581}{60}$ ÷ 36 - 15 = 6,584 CFM

Make-Up Air

$\frac{350}{14}$ × 77 (Δ gr) × 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 × $\frac{300,278}{60}$ ÷ 40 - 17 = 7,183 CFM Required

Proof

$\frac{7,500}{14}$ × (36 – 17) × 60 = 610,714 System Capability

DEHUMIDIFER REQUIRED VFB-75

PROCESS OUTLET TEMP. 135°F

Technical Resource Center

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

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; 7]°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'), 40penings/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 = $62.5 \times 55 \times 14 = 48{,}125$ ft.^{3}
C = 14 = constant
ΔG = 110 (Ambient 130 gr/lb - room 20 gr/lb)
F_1 = 2.76 from Table II – Factor for moisture difference of 110 gr/lb.
F_2 = 0.48 from Table III – for 48,125 cu. Ft.
F_3 = 1.0 from Table IV – Frame masonry & frame construction
F_4 = .9 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 openings
A = $6 \times 8 = 48$ sq ft
C = 7 = constant
ΔG = 110 grs/lb.
F_1 = 2.76 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.
F_1 = 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
F_1 = 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 x 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.

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

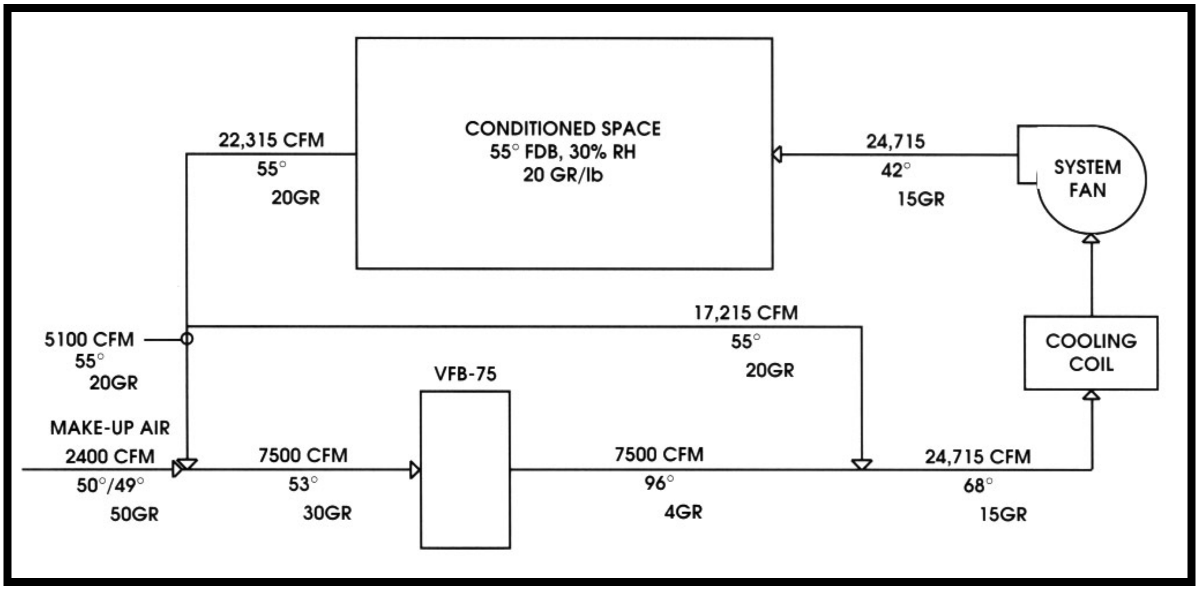
Total cfm = 24,715 cfm
14 = constant
S = 20 gr/lb. (condition of controlled space)
G = Unknown grain level needed entering space
60 = min/hr

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

G = 15.4 gr/lb.

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com
Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

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.



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

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.

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com

Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

Technical Resource Center

Bry-Air Dehumidifier Calculation Sheet
Project: Example IV – Controlled Humidity and Temperature Areas

Conditions				Room Size	
Surrounding	95 FDB	77 FWB	130 gr	62.5 L 55 W 14 H	= 48,125
Design	55 FDB	0 FWB	20 gr 30 RH	$\frac{48,125\ FT^3}{60}$	= 802
	40 Δ T		110 Δ gr		

Permeation — GR/HR

Volume: $\frac{48,125 FT^3}{14}$ × 110 (Δ gr) × 2.76 (F_1) × 0.48 (F_2) × 1 (F_3) × 0.9 (F_4) = 450,846

Door Load

Openings/hr: 6 × Area $\frac{48\ FT^2}{7}$ × 110 (Δ gr) × 2.76 (F_1) = 12,491

Openings/hr: 4 × Area $\frac{21\ FT^2}{7}$ × 110 (Δ gr) × 2.76 (F_1) = 3,643

Fixed Opening

2.8 (area) × $\frac{300}{14}$ × 10 (dep) × 110 (Δ gr) × 1.94 (F_1) = 1,822

People Load

10 (# people) × 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 × $\frac{479,802}{60}$ ÷ 20 - 2 = 6,220 CFM

Make-Up Air

$\frac{2,400}{14}$ × 30 (Δ gr) × 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 × $\frac{788,373}{60}$ ÷ 30 - 4 = 7,075 CFM Required

Proof

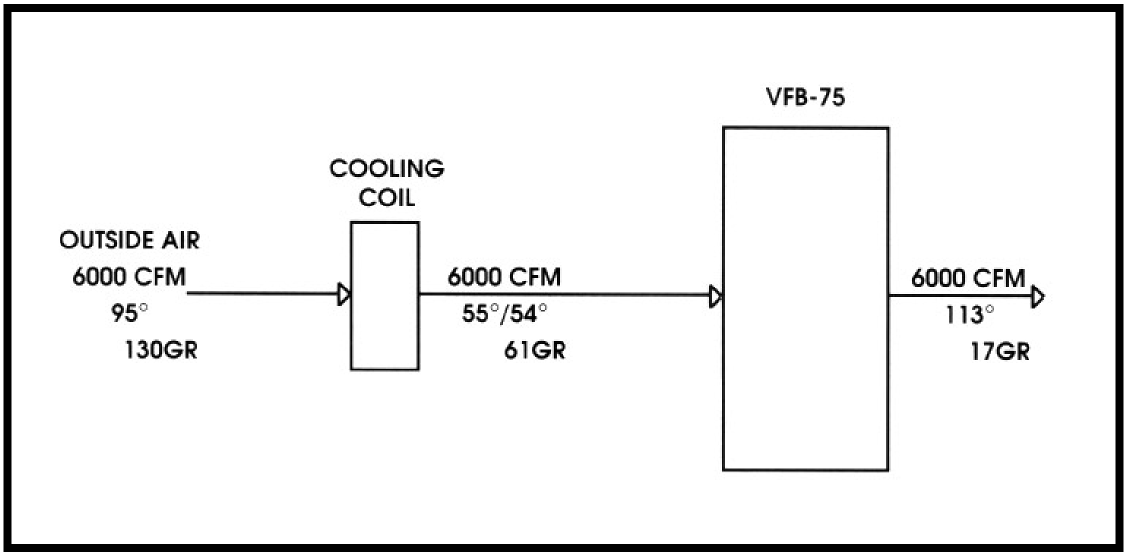
$\frac{7,500}{14}$ × (20 – 4) × 60 = 514,285 System Capability

DEHUMIDIFER REQUIRED VFB-75

PROCESS OUTLET TEMP. 96°F

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com
Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

Technical Resource Center



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.)

10793 State Route 37 W
Sunbury, OH 43074
www.bry-air.com
Toll-Free: (877) 427-9247
Phone: (740) 965-2974
Fax: (740) 965-5470

The use of an after-cooling coil for the dry air discharge from the dehumidifier can be omit-ted 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 tem-perature 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 compo-nents 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 means 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.