



THE OFFICIAL HANDBOOK • VERSION P – 1.0

INDUSTRY GUIDE FOR PAPER, PRINT & LABEL MANUFACTURING

FANMIST LOAD CALCULATOR GUIDE — THE PRACTICAL METHOD

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1000 psi High-Pressure Misting System with High-Velocity Fans

THE OFFICIAL GUIDE — A NOTE ON SCOPE

This handbook is organized as a step-by-step guide of the general **Practical Method** in calculating for total load (moisture required) to maintain your desired standard for control during winter manufacturing operations (e.g. 40% RH @ 70°F).



THE FOUNDATION • PREFACE

INTRODUCTION

WHERE THE GUIDE BUILDS FROM

Herrmidifier Corporation has served as mentor and guardian of the principles that have guided much of the broader industry of industrial-scale humidity control since its beginnings in 1945, first laid out in its own publication, the *Herrmidifier Load Calculator Guide*. This first edition of the *FanMist Load Calculator Guide* follows and builds on the foundation Herrmidifier set before us.

THE THREE FOUNDATIONAL QUESTIONS

That foundation starts in the same place every humidity control project does: with three simple questions, whose answers determine everything that follows. How much cubic air is actually being humidified? How fast is that air turning over? And what is the desired relative humidity percentage to be maintained? Together, the answers to these three questions define the moisture load — the total moisture that must be added — and that single figure, expressed in pounds per hour, is the foundation everything else is built on.

PHYSICS AS COLLABORATOR

From there, physics coupled with engineering takes over. The natural laws governing water, air, and evaporation are fixed; they set the rules in advance. Humidification becomes less a battle against the air and more a well-tuned collaboration with it. The design principle behind this is not new. It's time-tested: pairing high air velocity with high-pressure water atomization for accelerated evaporation — the natural laws do most of the remaining work automatically.

SCOPE OF THIS GUIDE

At the core of this Guide are the foundational first principles which form “the practical method” which is presented for real-world facility applications — it is the primary path through every calculation in the pages that follow. Where the full Comprehensive Method adds meaningful precision — for example, unusually high product throughput or detailed engineering documentation, this guide references its critical points directly rather than requiring a second, separate document.

HOW THIS GUIDE IS ORGANIZED

This Guide is organized in the same order a real sizing project takes form — from the physical problem, to the numbers behind it, to a finished piece of equipment.

"That which has been is what will be, that which is done is what will be done, and there is nothing new under the sun."

— Ecclesiastes 1:9



CRITICAL CONTROL • SECTION 01

PAPER & RELATIVE HUMIDITY

WHAT IS RELATIVE HUMIDITY (RH)?

RH measures water vapor in the air as a percentage of the maximum amount of water the air can hold at the current temperature and pressure:

- 100% RH = fully saturated (dew or condensation forms).
- 0% RH = theoretically impossible in real atmospheres.
- 50% RH = air holds half its maximum moisture capacity.

PAPER PRODUCTS & THE CRITICAL ROLE OF RELATIVE HUMIDITY

Paper and label substrates are hygroscopic — they naturally absorb or release moisture to reach equilibrium with the surrounding air. Stable RH prevents dimensional instability and boosts product quality, press efficiency, and profitability in paper, print, and label facilities.

Heated indoor air (68–72°F) in winter often reduces RH to dangerously low levels, pulling moisture from paper rolls, sheets, and substrates and causing defects. Adding controlled humidity with a FanMist humidification system maintains 40% RH at 70°F (up to 50% in some cases), stabilizing dimensions during unwinding, printing, die-cutting, laminating, and finishing.

EQUILIBRIUM MOISTURE CONTENT (EMC) & PAPER STABILITY

EMC is the moisture content (% of oven-dry paper weight) at which paper neither gains nor loses moisture. It depends almost entirely on temperature and RH.

WINTER TARGET

40% RH @ 70–72°F keeps paper EMC in the safe 4.8–6.2% range. This matches incoming stock and prevents:

- Paper curl and waviness
- Static electricity buildup
- Web breaks and misfeeds
- Print misregistration
- Poor ink adhesion and drying issues
- Dust attraction and label delamination

**TABLE 1-A
RELATIVE HUMIDITY %
& CORRESPONDING EMC %
(TYPICAL FOR UNCOATED PAPER
& LABEL STOCK)**

RH	EMC (%)
30%	4.1 – 4.3%
35%	4.5 – 4.7%
40%	4.8 – 6.2%
45%	5.5 – 6.8%
50%	6.2 – 7.5%

RECOMMENDED PRACTICES FOR PAPER/PRINT/LABEL HUMIDITY CONTROL

- Acclimate paper rolls and sheets to shop conditions before processing.
- Use climate-controlled storage for finished labels and converted products.
- Monitor consistent EMC plant-wide with a hygrometer.



CENTRAL CONCEPTS • SECTION 02

CORE ENGINEERING PRINCIPLES

GOVERNING AIRFLOW

Accurate humidification load calculations are based on understanding air balance within the plant area to be humidified. The single most important value is **the governing airflow** — the greater of:

- **Total process CFM's:** exhaust CFM or total makeup-air CFM (including the HVAC economizer's minimum outdoor-air setting).

– OR –

- **Air Exchanges per Hour (ACH):** when CFM's are not identified, use an estimated air exchange rate based on building construction — tight, well-sealed construction: 1.0 ACH; average construction: 1.5 ACH; loose construction, multiple exposed walls, or frequent shipping-door traffic: 2.0 ACH (see Required Building Data section for detail).

Whichever method is used, the resulting governing airflow becomes the basis for all load calculations.

GRAINS/FT³ DIFFERENCE

Grains/ft³ Difference is the actual moisture deficit the system must supply, after accounting for the moisture already present in the heated incoming outdoor air. Because heating outdoor air lowers its relative humidity without changing its actual water content, some of that moisture is already available to offset the load — the guide credits this conservatively, retaining 50% of the outdoor air's saturation value at design temperature:

Grains/ft³ Difference = the target indoor moisture content (gr/ft³ at the desired relative humidity and indoor temperature) minus the available moisture from heated outdoor air, where available moisture is the saturation value at design winter outdoor temperature multiplied by the conservative 50% retention factor.

LOAD

Load is the central concept of this guide. Load always refers to the total amount of moisture — in pounds of water vapor per hour — that the FanMist system must add to the air to bring it from its incoming moisture content up to the target relative humidity level under design winter conditions.

FINAL SYSTEM CAPACITY

Final System Capacity is Load + 15% safety margin — accounting for colder-than-design temperatures and minor variations in operating conditions.

This progression — Grains/ft³ Difference, Load, Final System Capacity — is the foundation for all load calculations.

Load (lbs/hr) = Grains/ft³ difference × (Governing CFM × 60) ÷ 7,000 grains/lb_w

Final System Capacity (lbs/hr) = Load × 1.15



AIR BALANCE & GOVERNING AIRFLOW • SECTION 03

VENTILATION vs. INFILTRATION

HOW OUTDOOR AIR ENTERS A BUILDING, AND WHY IT ALL BECOMES ONE NUMBER

Every load calculation begins with one question: how much outdoor air is entering the building? That air is cold, holds little moisture, and must be brought up to target humidity — regardless of how it got in. Outdoor air enters through two different paths, and the relationship between them is what makes the governing-airflow calculation meaningful rather than arbitrary.

VENTILATION is the deliberate, engineered exchange of air with the outdoors — process exhaust systems (dust collection, spray booths, fume extraction) pulling air out, and makeup-air units, HVAC economizers, or supply fans bringing tempered air back in. Ventilation is measured and usually preconditioned before it reaches the space.

INFILTRATION is the uncontrolled counterpart: outdoor air leaking in through door gaps, dock doors, wall penetrations, and envelope imperfections. It's what happens automatically whenever a building's air balance falls short.

That's the key connection. Air balance is the relationship between exhaust-air CFM and makeup-air CFM, and it determines how much of a building's air exchange is engineered ventilation versus unmanaged infiltration filling the gap:

- **Balanced (exhaust $\approx$ makeup):** Neutral pressure. Infiltration is minimal, and measured makeup-air CFM is a trustworthy load input.
- **Negative pressure (exhaust $>$ makeup):** The building pulls more air out than it replaces, so the shortfall is drawn in through available gaps. Exhaust CFM effectively stands in for the infiltration it's inducing.
- **Positive pressure (makeup $>$ exhaust):** More air is pushed in than removed, forcing indoor air out through gaps instead. Infiltration is suppressed, sometimes at the cost of excess conditioning capacity.

This is why the governing-airflow rule reads: use the greater of total exhaust CFM or total makeup-air CFM. Whichever side is larger is driving the most outdoor-air exchange, and in an imbalanced building, that figure implicitly captures the infiltration the smaller one leaves out.

Where CFM figures aren't available, the guide falls back to an estimated Air Exchanges per Hour (ACH), tiered by construction — tighter buildings infiltrate less and get a lower ACH; looser buildings or frequent shipping-door traffic get a higher one. See Required Building Data (Section 04) for the specific values.

ONE NUMBER, TWO SOURCES

Ventilation and infiltration are two expressions of the same air balance, not competing sources of outdoor air. A building's exhaust-to-makeup relationship determines how much of its air exchange is deliberate versus incidental — and the governing-airflow figure captures that combined total as one usable load-calculation input.



ESSENTIAL INPUTS • SECTION 04

REQUIRED BUILDING DATA

FIVE MAIN FACTORS FOR LOAD CALCULATIONS

Must-know factors for every area or zone targeted for humidity control:

1 TOTAL CUBIC AIR SPACE (VOLUME)

Measure the dimensions of the area(s) to be humidified: length × width × ceiling height (in feet). This gives the total volume in cubic feet (ft³) — the "air mass" that must be humidified.

2 AIR EXCHANGE RATE PER HOUR (ACH) OR EXHAUST/MAKEUP AIR CFM

This tells you how quickly the air volume in the space is replaced — using one of two measurements: Air Exchanges per Hour (ACH) or exhaust/makeup-air CFM.

- Use Air Exchanges per Hour (ACH) when exhaust/makeup CFM data is unavailable, or for infiltration estimates:
 - Tight, well-sealed construction — 1.0 ACH
 - Average construction — 1.5 ACH
 - Loose construction, multiple exposed walls, or frequent shipping-door traffic — 2.0 ACH
- *(Never use less than 1.0 ACH unless the area is fully sealed with no traffic)*
- Prefer CFM data when available — it is more accurate for controlled systems. Always use the greater of total exhaust CFM or makeup-air CFM. To convert CFM to cubic feet per hour: CFM × 60.

3 DESIRED HUMIDITY STANDARD (TARGET CONDITIONS)

Example: 40% RH at 70°F (saturation = 8.10 gr/ft³ → target moisture content = 3.24 gr/ft³). This defines the target moisture level in the space.

4 OUTDOOR DESIGN TEMPERATURE

Use your local average coldest winter temperature (e.g., 0°F, or a site-specific value) for worst-case dry-air conditions.

5 PSYCHROMETRIC DATA

All calculations rely on a Psychrometric Saturation Table (grains of water vapor per cubic foot of saturated air at 100% RH), or equivalent chart values, for indoor and outdoor conditions.

SPECIAL CONSIDERATION FOR PROCESS EXHAUST

From: press exhaust, fume extraction and converting-line exhaust (flexo presses, die cutters, laminators, slitters). Return filtered air indoors during winter typically lose 10–20% of the airflow (leaks, pressure relief, etc.). Add the lost portion to total exhaust CFM.

Example:

Fully-Exhausted Process Air (press/laminator exhaust — VOC/heat-laden, not returned) = **42,000 CFM**

Recirculating Process Exhaust (die cutters, slitters — filtered air returned indoors) = 40,000 CFM, with ~15% loss → add 6,000 CFM loss

Total Exhaust = 48,000 CFM (always use the greater of exhaust-air or makeup-air CFM)



PSYCHROMETRIC ESSENTIALS • SECTION 05

THE PSYCHROMETRIC TABLE

READING THE TABLE

Load calculations rely on the Psychrometric Saturation Table showing how much moisture — in grains/ft³ — air can hold at 100% saturation for a given temperature. For example, at 70°F, 100% saturated air holds 8.10 grains/ft³.

Table 2-A Grains of Water Per Cubic Foot – Saturated Air (100% RH)														
°C	°F	Grains	°C	°F	Grains	°C	°F	Grains	°C	°F	Grains			
-23	-10	0.29	4	40	2.86	58	5.41	76	9.75	94	16.79			
	-5	0.35		41	2.97		59	5.60		35	95	17.28		
-18	0	0.48		42	3.08	16	60	5.80		78	10.40	96	17.80	
	5	0.61		43	3.20		61	6.00		79	10.80	97	18.31	
-12	10	0.70		44	3.32		62	6.20	27	80	11.04	8	18.85	
-9	15	0.99	7	45	3.44		63	6.41		81	11.40	99	19.39	
-7	20	1.24		46	3.56		64	6.62		82	11.75	38	100	19.95
-4	25	1.56		47	3.69	18	65	6.85		83	12.11	101	20.52	
-1	30	1.95		48	3.83		66	7.07		84	12.49	102	21.11	
	31	2.04		49	3.97		67	7.31	29	85	12.87	103	21.71	
	32	2.13	10	50	4.11		68	7.57		86	13.27	104	22.32	
	33	2.21		51	4.26		69	7.80		87	13.67	41	105	22.95
	34	2.29		52	4.41	21	70	8.10		88	14.08	106	23.60	
2	35	2.38		53	4.56		71	8.32		89	14.51	107	24.26	
	36	2.47		54	4.72		72	8.59	32	90	14.94	108	24.93	
	37	2.56	13	55	4.89		73	8.87		91	15.39	109	25.62	
	38	2.66		56	5.06		74	9.15		92	15.84	43	110	26.34
	39	2.76		57	5.23	24	75	9.45		93	16.31	111	27.07	

KEY CONVERSION: 7,000 GRAINS = 1 POUND OF WATER.

HOW TO CALCULATE GRAINS/FT³ DIFFERENCE

- 1 Look up the grains/ft³ value at your target indoor temperature and multiply by desired RH%.
Example: 40% RH @ 70°F = 0.40 × 8.10 grains/ft³ at 70°F = 3.24 grains/ft³.
- 2 Look up the grains/ft³ value at the outdoor winter design temperature (commonly 0°F = 0.48 grains/ft³) and apply the conservative 50% retention factor (heated incoming air retains only half its original moisture).
Example: 0.50 × 0.48 grains/ft³ = 0.24 grains/ft³.
- 3 Subtract: Grains/ft³ Difference = Indoor target grains – Outdoor grains (50% retention).
Example: 3.24 grains/ft³ – 0.24 grains/ft³ = 3.00 grains/ft³ (This value is used directly in the load calculation formula).



CALCULATIONS • SECTION 06

THE PRACTICAL METHOD

TWO FORMULAS

The practical sizing method accounts for 80–95% of all factors for determining total load, including application of a safety margin. Secondary factors are generally ignored, although factored in as part of the safety margin.

FORMULA #1 **PREFERRED**

Step-by-Step Practical Sizing Method Using Formula #1 – Based on Plant Area(s) CFM to determine the governing CFM the Greater of Either Exhaust – OR – Makeup Air.

- 1 Determine governing CFM = greater of total process exhaust CFM or total makeup-air CFM (including HVAC economizer minimum outdoor-air setting).
- 2 Convert to hourly volume: Governing CFM $\times$ 60 = ft³/hr.
- 3 Obtain Grains/ft³ Difference from the Psychrometric Table.
- 4 Calculate Load:
Load (lbs/hr) = Grains/ft³ Difference $\times$ (Governing CFM $\times$ 60) $\div$ 7,000 grains/lb_w.
- 5 Final System Capacity (in lbs/hr of water): Apply 15% safety margin to the Load (this extra capacity handles occasional colder temperatures and ensures reliable performance without oversizing the system).

FORMULA #2

Step-by-Step Practical Sizing Method Using Formula #2 — Based on Plant Area(s) cubic air space & air exchange rate per hour (ACH). This formula is used when CFM data is not known, with building cubic air space volume used in conjunction with an estimated air-change rate/hour.

- 1 Calculate total volume = Length $\times$ Width $\times$ Ceiling Height = ft³.
- 2 Select appropriate ACH (1.0–2.0).
- 3 Convert to hourly volume: Total ft³ Volume $\times$ ACH = ft³/hr.
- 4 Calculate Load:
Load (lbs/hr) = Grains/ft³ Difference $\times$ (Total Volume in ft³ $\times$ ACH) $\div$ 7,000 grains/lb_w.
- 5 Final System Capacity (in lbs/hr of water): Apply 15% safety margin to the Load (this extra capacity handles occasional colder temperatures and ensures reliable performance without oversizing the system).

FINAL SYSTEM CAPACITY — APPLIES TO BOTH FORMULA #1 AND FORMULA #2

$$\text{Final System Capacity} = \text{Load} \times 1.15$$



ILLUSTRATIVE EXAMPLE • SECTION 07 • PART 1 OF 2

PAPER PLANT

PRACTICAL METHOD FOR SIZING

A large-scale, 96,000 ft² paper, print & label converting facility located in the Midwest operates high-volume flexographic presses, die cutters, and laminators. It is a self-contained, rectangular structure, operating with conditioned makeup air to maintain slight positive building pressure. This plant will serve as our example throughout this guide.

EXAMPLE BUILDING DATA APPLIED TO FORMULA #1 (CFM BASIS)	
Dimensions of area(s) to be humidified	400' (W) x 240' (L) x 30' Ceiling
Total Cubic air space of area(s) to be humidified	2,880,000 ft ³
Equipment exhaust (presses, die cutters, laminators)	48,000 CFM
Makeup-air (MAU, governing)	52,000 CFM
Target indoor conditions (Desired RH to be maintained)	40% RH @ 70°F
Saturation @ 70°F	8.10 gr/ft ³
Target moisture content @ 40%	3.24 gr/ft ³
Outdoor design condition	0°F @ 100% RH
Saturation @ 0°F = .48 gr/ft ³ @ 50% retention	0.24 gr/ft ³
Grains/ft ³ Difference: 3.24 gr/ft ³ (target) – 0.24 gr/ft ³ (available)	3.00 gr/ft ³
Governing CFM × 60 (52,000 CFM × 60 minutes)	3,120,000 ft ³ /hr
Converting lbs/hr to gpm: lbs/hr ÷ 500 (8.34 lbs/gallon × 60 min/hr = 500.4)	—

APPLYING FORMULA #1 TO THE BUILDING DATA

$$\text{Load (lbs/hr)} = 3.00 \text{ gr/ft}^3 \times 3,120,000 \text{ ft}^3/\text{hr} \div 7,000 \text{ grains/lb}_w = 1,337 \text{ lbs/hr}$$

FINAL SYSTEM CAPACITY

$$\text{Load (lbs/hr)} \times 1.15 \text{ (15\% Safety Margin)} = 1,538 \text{ lbs/hr (3.08 gpm)}$$

FINAL SYSTEM CAPACITY — MIDWEST PAPER & LABEL CONVERTING PLANT
1,538 lbs/hr (3.08 gpm)



ILLUSTRATIVE EXAMPLE • SECTION 07 • PART 2 OF 2

PAPER PLANT

COMPREHENSIVE METHOD FOR SIZING

The comprehensive method is the result of the practical method plus accounting for secondary load factors, which provide an adjustment for precise load calculations. These factors are frequently small relative to the ventilation load and often partially offset one another. They are still worth quantifying for high-throughput shops or tight tolerance targets.

1. PRODUCT REGAIN (*moisture sink — increases load*)

Dry incoming paper rolls, sheets, or other substrate stock absorb moisture from the shop air as they reach equilibrium moisture content (EMC). This acts as a moisture sink, increasing the humidifier output required.

Estimate based on daily or hourly paper throughput (pounds or tons), incoming moisture content, and target EMC (typically 4–6% at 35–50% RH). For high-volume converting plants, this can add several lb/hr to the load; for lower-throughput areas, it may be negligible.

2. PROCESS VAPORS (*moisture gain — decreases load*)

Water-based inks, adhesives, coatings, laminating, and certain cleaning or drying processes release water vapor into the air, partially offsetting the need for humidification. Obtain rates from equipment manufacturers where available. In printing and label production these gains are often modest but should be quantified where present.

3. PEOPLE BREATHING AND PERSPIRATION (*moisture gain — decreases load*)

Occupants release moisture through respiration and activity. For light bench or standing shop work, use approximately 0.1–0.2 lb/hr per person (latent moisture only). Multiply by the average number of workers in the

Comprehensive Method = 1,337 lbs/hr (ventilation) + Product Regain – Process Vapors – People

FINAL ADJUSTED LOAD WITH SECONDARY FACTORS

Adjusted Load (lb/hr) = Ventilation Load + Product Regain (moisture sink) – Process Vapors (moisture gain) – People (moisture gain)

Adjusted Load = 1,337 lbs/hr (ventilation) + Product Regain – Process Vapors – People



SIZING • SECTION 08 • PART 1 OF 3

FORMULAS APPLIED TO BUILDING DATA

EXCEL SPREADSHEET CALCULATIONS

An IHC excel spreadsheet using embedded cell values for all calculations from the building data for load calculations according to Formula #1 and Formula #2.

EXAMPLE BUILDING DATA — PSYCHROMETRIC DATA — CALCULATIONS — SIZING																				
	A L	B W	C H	D ft ²	E ft ³	F ExA	G MuA	H RH	I T°	J Gr	K TMC	L 0°Gr	M %	N GD	O A	P lbs/hr	Q 15	R FSC	S GPM	T 111.16
Formula #1 (CFM)	400	240	30	96,000	2,880,000	48,000	52,000	40%	70°	8.10	3.24	0.48	0.24	3.00	60	1,337	2011,538	3.08	13.84	
Formula #2 (ACH)	400	240	30	96,000	2,880,000	—	—	40%	70°	8.10	3.24	0.48	0.24	3.00	1.08	1,337	2011,538	3.08	13.84	

Formula #1 (CFM) is always preferred for load calculations. Formula #2 (ACH) based on 1.08 Air Exchanges / hour.

SPREADSHEET CELL DEFINITIONS AND EMBEDDED CELL FORMULAS FOR COLUMNS A-T

Col	Definition	Embedded Cell Formula and/or Raw Data
A-C	L (Length) W (Width) C (Ceiling Height)	Dimensions in feet for area to be humidified
D	Ft² (total square feet)	A x B
E	Ft³ (total cubic feet)	A x B x C
F	ExA (Exhaust-Air)	Entered as CFM with cell coded for number
G	MuA (Makeup-air)	Entered as CFM (Governing) with cell coded for number
H	RH (Desired Relative Humidity %)	Entered as number with cell coded for %
I	T° (Average Indoor Winter Air Temperature)	Entered as temperature with cell coded for number
J	Gr (Grains of I Temperature at Saturation)	Entered gr/ft ³ from the Psychrometric Table corresponding to I
K	TMC (Target Moisture Content gr/ft ³)	J x H
L	0° Gr (gr/ft ³ of Outside Air)	gr/ft ³ from the Psychrometric Table corresponding to the outdoor design temp
M	% (gr/ft ³ of Outside Air, retained)	L x 50%
N	GD (Grains Difference gr/ft ³)	K - M
O	A (Plant Air Turnover Rate)	Expressed as 60 minutes (formula #1) OR as ACH, e.g. 1.08 (Formula #2)
P	lbs/hr (Load)	N x (G x O) ÷ 7,000 — Note: using 60 minutes for O
Q	15% (safety margin)	15% x P
R	FSC (Final System Capacity in lbs/hr)	P + Q
S	GPM (Gallons per Minute)	R ÷ 500
T	Fans (Total number of fans in the system)	R ÷ 111.16 lbs/hr/fan (fan + mist ring + number & size of nozzles)

FINAL SYSTEM CAPACITY (Formula #1 – CFM)

Final System Capacity (lbs/hr) = [Grains/ft³ difference x (Governing CFM x 60) ÷ 7,000 grains/lb_w] x 1.15



SIZING • SECTION 08 • PART 2 OF 3

SYSTEM EQUIPMENT SIZING

SIZING COMPONENTS

System Components are selected and sized by the Final System Capacity of 1,538 lbs/hr (3.08 gpm) to maintain 40% RH @ 70°F with 52,000 CFM makeup-air as our governing airflow

PUMP STATION

Required minimum 1,538 lb/hr (3.08 gpm). Size: 2 each 1.75 gpm stations = 3.5 gpm total (3.08 required)— Note: add excess in intervals of 0.25 gpm, favoring excess up to 0.4 gpm; never allow pump excess capacity to exceed 50% of pump rated total capacity).

Excess Capacity: $3.5 \text{ gpm} - 3.08 \text{ gpm} = .42 \text{ gpm excess (210 lbs/hr)}$

FANS MIST RINGS, NOZZLES, TUBE & SLIP-LOKS

13.84 total number of fans required — sized with 14 fans w/ 27" Mist Rings (14 each 7.94 lb/hr nozzles) @ 111.16 lb/hr/fan = 1,556.24 lbs/hr total output. From each pump station, 1/2" tube line splits into two 3/8" legs, one leg to four fans, one leg to three fans — 7 fans per pump station (sizing rule – five fans maximum per one 3/8" tube line).

LOCATING FANS

Use the natural flow of makeup air moving toward exhaust points in the plant. Locate fans upstream from exhausting points within the mechanical airflow patterns to take full advantage of fan placement, maximizing hang time of humidity in the air while filling all air space to equilibrium as it flows to exhausting locations.

CONTROLS

Two wall-mounted humidistats (one per pump) tied to the PLC controller for automatic synchronized fan/pump system ON/OFF operation — ensures 100% evaporation and maintains uniform 40% RH set-point at 70°F throughout the 2,880,000 ft³ space.

WATER TREATMENT

Size water treatment to be 1.5 times the capacity of pump(s) total rated gpm.

EVAPORATION RATE – CFM : LBS/HR LOADING RATIO

The evaporation rate (ER) of 1000-psi atomized water combined with fan airflow is governed by the Loading Ratio (CFM of air per lb/hr of water). This ratio determines how effectively the mist evaporates beyond atomization alone.

36" Fan @ 10,000 CFM — Nozzles @ 7.94 lbs/hr — 27" Mist Ring @ 111.16 lbs/hr_w
Evaporation Rate = 89.96 CFM : 1 lb/hr_w



SIZING • SECTION 08 • PART 3 OF 3

EQUIPMENT & PART NUMBERS

BILL OF MATERIALS — SIZED FOR 14 FANS / 2 PUMP STATION — FANMIST SYSTEM

Qty	Part #	Description
2	APS175-4	Automated Pump Station 1.75 gpm • 3 ph • EDV • HPS • 24 VAC • Indicator Lights & Hour Meter
2	HRO20	Humidistat (Neptronic) Built in sensor – Signals the on/off pump • 24/7 RH Set Point RH Control
2	90063	3/8" High-Pressure Flexible Nylon Tube, 500' Roll
50	92714	3/8" Vinyl Coated Steel Wall Clamps
1	90550	1/2" High-Pressure Flexible Nylon Tube, 500' Roll
20	92680	1/2" Vinyl Coated Steel Wall Clamps
12	92702	3/8" SS Slip-Lok Coupling
6	92703	3/8" SS Slip-Lok 90° Elbow
14	92704	3/8" SS Slip-Lok Three Way Tee
4	95702	1/2" SS Slip-Lok Coupling
2	95703	1/2" SS Slip-Lok 90° Elbow
4	95704	1/2" SS Slip-Lok Three Way Tee
4	92709	3/8" Slip-Lok x 3/8" FNPT (transition fitting from 3/8")
4	92854	1/2" Slip-Lok x 3/8" MNPT (transition fitting from 1/2")
14	VBS36CF	36" Fan – High Velocity Cage Fan 1/2HP 3Ph (230/460) 9910 CFM includes bracket
14	93711	27" Diameter Mist Ring (Bare) w/ 14 nozzle ports - 10/24 UNC thread
28	92707	3/8" Slip-Lok x 3/8" MNPT adapter (Ball Valve Assembly: two per Mist Ring)
14	92632	3/8" Stainless Steel Ball Valve with 3/8" FNPT ports (Ball Valve Assembly: one per Mist Ring)
14	93163	3/8" Slip-Lok x 1/8" MNPT adapter (Ball Valve Assembly: one per Mist Ring)
200	7.94N	7.94 lbs/hr (Blue Band) Orifice: 0.2 mm / 0.008" – 0.016 gpm

MAINTENANCE & SPARES PAK

30	7.94N	7.94 lbs/hr (Blue Band) Orifice: 0.2 mm / 0.008" – 0.016 gpm
20	93505	Nozzle Plug 10/24 Male UNC
1	93711	27" Diameter Mist Ring (Bare) w/ 14 nozzle ports - 10/24 UNC thread
2	92707	3/8" Slip-Lok x 3/8" MNPT adapter (Two per Mist Ring)
1	92632	3/8" Stainless Steel Ball Valve with 3/8" FNPT ports
1	93163	3/8" Slip-Lok x 1/8" MNPT adapter
2	95062	Filter wrench for 92609 (10" Filter Housing) - 1 per Pump Station
2	92608	9 3/4" Pre-filter 5 micron cartridge for 92609 - 1 per Pump Station
4	93222	16 oz GP Series Pump Oil – 30 weight (2 per Pump Station)
2	94506	6" Nozzle Extension SS for high-pressure line flushing procedure

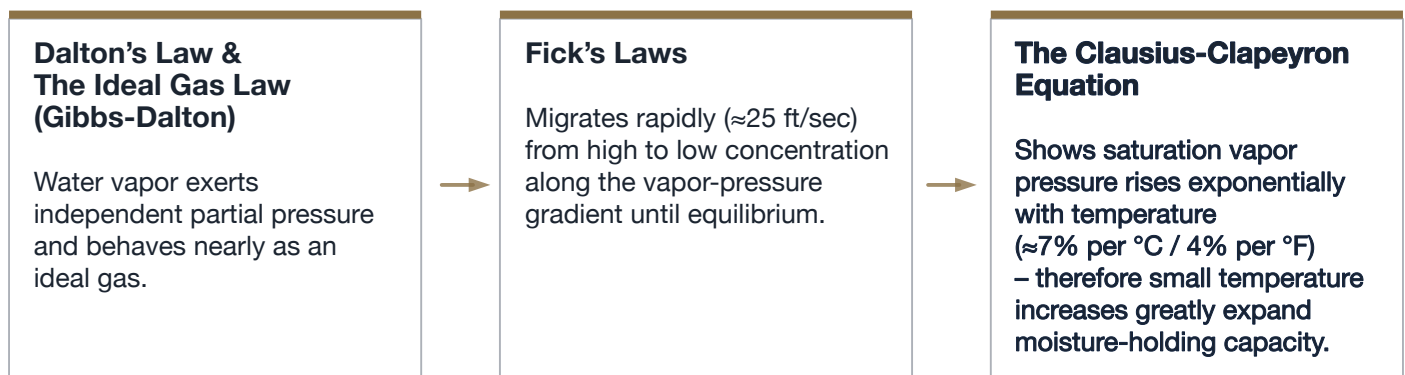


VERITIES • SECTION 09

FIRST PRINCIPLES – PHYSICAL LAWS

HIGH-VELOCITY AIR + 1000-PSI ATOMIZATION = ACCELERATED EVAPORATION

THREE PHYSICAL LAWS WORKING TOGETHER GOVERN HOW HUMIDITY EQUALIZES TO A STATE OF EQUILIBRIUM



Accelerated evaporation is the combination of fan air velocity CFM with high-pressure (1000-psi) water atomization – rapidly converting fine droplets of moisture to vapor within a controlled air plume. The design principle: maintain fan output ratio above **75 CFM : 1 lb of water** – within a 4 ft diameter / 22 ft length plume for complete evaporation.

THIS PERFORMANCE RESTS ON SEVEN INTERDEPENDENT ELEMENTS:

- 1 **Extremely fine droplet size** – with very high surface-area-to-volume ratios, enabling rapid phase change.
- 2 **High air movement and mixing** – Elevated CFM keeps droplets suspended and continuously supplies unsaturated air.
- 3 **Strong vapor-pressure gradient** – Moving air maintains a large difference between actual & saturation vapor pressure, driving fast evaporation.
- 4 **Temperature influence** – Warmer “ceiling” air increases moisture-holding capacity, further accelerating the process.
- 5 **Rapid diffusion and equalization** – Once evaporated, water vapor migrates quickly throughout the connected air space.
- 6 **Precise system design & placement** – Sizing fan, mist-ring, and nozzles positioned to inject moisture into the high-velocity air stream within the defined plume dimensions – positioned and pointed into obstacle-free air spaces.
- 7 **Continuous dilution of near-saturated air** – Sufficient air volume & velocity prevent localized saturation, sustaining high evaporation rates.

Together these factors allow the atomized moisture to be fully evaporated inside the fan's moisture plume without fallout, delivering efficient, uniform humidity distribution.



TEAR OUT REFERENCE • PAPER, PRINT & LABEL EDITION • SECTION 10

QUICK LOAD CALCULATOR CARD

A field-ready worksheet using the Recommended Practical Sizing Method — Ventilation Load plus a 15% safety margin — for paper, print and label production facilities.

TARGET RH% FOR PAPER

Sweet spot: 40% RH at 70–72°F (up to 50% RH in some operations) — Maintains paper EMC 4.8-6.2% range.

1 Building Cubic Air Volume

Width _____ × Length _____ × Height _____ ≈ _____ ft³

2 Governing Airflow (CFM)

Use the greater of total exhaust CFM (include dust-collection losses — typically 10–20% of intended return air) or total makeup-air CFM. Governing CFM = _____ — OR — Estimated ACH = _____

3 Target Indoor Conditions

Desired RH: _____% (35–45% typical) @ average winter indoor air temperature: _____°F

Saturation moisture content @ 100% (Table 2-A) ≈ _____ gr/ft³

4 Outdoor Design Conditions

Outdoor winter design temperature: _____°F @ 100% saturation (Table 2-A) = _____ gr/ft³

Available outdoor moisture (50% retention) ≈ _____ gr/ft³

5 Grains Difference

Target indoor moisture _____ gr/ft³ – Available outdoor moisture _____ gr/ft³

= Grains/ft³ difference ≈ _____ gr/ft³

6 Ventilation Load (lb/hr)

Grains/ft³ × Governing CFM × 60 ÷ 7,000 grains ≈ _____ lbs/hr

7 Final FanMist System Capacity

Ventilation Load × 1.15 (15% safety margin) ≈ _____ lbs/hr ≈ _____ gpm at 1,000 psi (lbs/hr ÷ 500)

8 Fan Count Check (Loading Ratio)

1 each fan @ rated _____ CFM ÷ fan lbs/hr capacity _____ lbs/hr ≈ _____ CFM : 1 lb/hr

(Should exceed minimum of 75 CFM : 1 lb/hr)

IMPORTANT NOTES

- When makeup-air includes an HVAC economizer, use its minimum outdoor-air setting (the winter-design operating point) as the makeup-air CFM figure — then compare against exhaust CFM per the governing-airflow rule and use the greater of the two.
- Secondary factors (product regain, people, process vapors) are intentionally omitted — they rarely change the final equipment size.
- Always maintain slight positive building pressure (+0.01 to +0.05 in. w.c.) to minimize infiltration.



APPENDIX REFERENCE

APPENDIX A

GOVERNING AIRFLOW — CHOOSING BETWEEN EXHAUST-AIR (ExA) AND MAKEUP-AIR (MuA)

Section 02 and Section 03 establish the core governing-airflow rule: always use the greater of total exhaust CFM (ExA) or total makeup-air CFM (MuA) as the basis for every load calculation. The sizing spreadsheet in Section 08 (Part 1 of 3) enters these as two separate columns — F (ExA) and G (MuA) — but its Load formula (Column P) references Column G directly, rather than automatically selecting whichever of the two is larger.

This is a deliberate simplification, not an oversight in the underlying rule. In the Paper Plant worked example (Section 07), makeup-air governs — 52,000 CFM versus 48,000 CFM of process exhaust — so entering the figures directly into Columns F and G happens to produce the correct result. Nothing in the spreadsheet enforces that outcome, however; it depends entirely on which values are entered where.

Before entering figures into Columns F and G, compare them directly. Whichever is larger is the one that should carry through the Load formula. In practice, that means one of two approaches:

- **If makeup-air is larger** (the typical case, and the one shown throughout this guide): enter it into Column G as usual — the spreadsheet works as built.
- **If exhaust airflow is larger** — a negative-pressure building, per Section 03 — enter the exhaust value into Column G instead, so it drives the Load formula, and note the makeup-air figure in Column F for reference only.

A facility with exhaust CFM meaningfully larger than makeup-air CFM is running under negative pressure, drawing the shortfall in through infiltration — see Section 03 for the full discussion of why this makes exhaust CFM the more representative figure in that scenario. This is worth double-checking in shops with high-volume dust collection systems: if a dust collector's rated CFM (plus its 10–20% return-air loss, per Section 04) exceeds the makeup-air unit's capacity, exhaust — not makeup-air — is the figure that should drive the Load formula. Reversing Columns F and G is the single most common way this spreadsheet under-sizes a system, since the Load formula has no built-in safeguard against it.

SPREADSHEET TIP

If you maintain your own working copy of this spreadsheet, consider adding a helper column — e.g., "Governing = MAX(F,G)" — feeding that into the Load formula instead of Column G directly. This removes the manual comparison step and prevents the sizing error described above.



APPENDIX REFERENCE

APPENDIX B

TARGET RH "SWEET SPOT" — EXTENDED REFERENCE

Section 01 (Paper & Relative Humidity) establishes the guide's core target: 40% RH at 70-72°F (up to 50% RH in some operations), keeping paper EMC in the 4.8–6.2% safe range. This appendix expands on the practical reasoning behind that range for anyone selecting a set point for a specific facility or product line.

Substrate and process-specific adjustment: coated stocks, uncoated stocks, and film-based label substrates respond to humidity swings at different rates — uncoated, absorbent stocks and thin label webs respond fastest, and benefit from staying nearer the upper half of the sweet spot during acclimation. Facilities running converting alongside high-speed press or laminating lines may find it worthwhile to set slightly different targets by zone rather than a single plant-wide value — the load calculation in Section 07 can be re-run per zone using that zone's own volume and governing airflow.

SCOPE NOTE — FILM SUBSTRATES

Scope note — film substrates: this guide's EMC-based sizing logic (Table 1-A, and the reasoning below) applies to hygroscopic paper and uncoated/coated paperboard stock. Film-based label substrates (BOPP, vinyl, polyester, and similar) are not meaningfully hygroscopic and do not reach an equilibrium moisture content the way paper does — humidity control on a pure-film line is still valuable, but the driver is static-charge and dust control (see below) rather than dimensional stability, and EMC targets from Table 1-A should not be applied to film-only substrates.

Table 1-A (Section 01) remains the reference for translating any RH set point in the 30–50% range into its corresponding EMC — consult it directly whenever evaluating a target outside the 40% default used in this guide's worked example.

NOTE ON TABLE 1-A

The EMC ranges in Table 1-A widen sharply starting at the 40% RH row (4.8–6.2%, a 1.4-point span) compared to the tighter 0.2-point spans at 30% and 35% RH, and the 40% row's upper bound (6.2%) exactly matches the 50% row's lower bound. This pattern is carried directly from the source document and may reflect a genuine widening in real paper hygroscopicity data at higher RH — but it is worth confirming against your EMC reference of choice before publishing, since it reads differently from a typical smooth EMC curve.

WHY THIS RANGE — NOT SIMPLY "HIGHER IS SAFER"

RH above roughly 50% at typical shop temperatures begins to risk mold and fungal growth in stored paper rolls, over-absorption and cockle/waviness, and slowed ink and coating curing — trading one set of defects for another. RH below 35–40% re-exposes the shop to the original problem the FanMist system is solving: paper curl, static electricity buildup, and web breaks.



APPENDIX REFERENCE

APPENDIX B CONTINUED

STATIC ELECTRICITY — THE OVERLOOKED HALF OF THE RH STORY

EMC and dimensional stability explain why the sweet spot has a floor and a ceiling, but they are not the only reason low RH is dangerous in paper, print, and label facilities. Paper's surface resistivity rises sharply as its moisture content drops, because the thin layer of adsorbed water that normally allows small static charges to bleed off the web is no longer present in sufficient quantity. Below roughly 30–35% RH, charge generated by unwinding, slitting, and high-speed web contact with rollers and guides can no longer dissipate fast enough, and it accumulates instead — leading to web clinging and misfeeds, sheets jumping or fanning at the delivery stack, print misregistration from web flutter, dust and debris attraction to the charged web, and in severe cases visible static discharge that can damage sensitive electronic controls or, near solvent-based inks and coatings, pose an ignition risk.

This is why the guide's 40% RH target sits meaningfully above the ~30–35% static-risk threshold rather than just above the EMC-defect threshold in Table 1-A — the two mechanisms have different floors, and the target needs to clear both with margin. Facilities running especially fast web lines, or handling low-moisture film/foil laminate structures where static risk is elevated even with adequate paper-side RH, may find it worthwhile to hold the upper half of the sweet spot (closer to 45–50% RH) specifically for sta



APPENDIX REFERENCE

APPENDIX C

HVAC & THE ECONOMIZER CYCLE — FULL DISCUSSION

How Economizers Affect Winter Makeup-Air CFM

In most industrial buildings, the HVAC system's economizer is one of the largest sources of controlled makeup air. The economizer modulates outdoor-air dampers year-round: it opens wider during mild weather and shoulder seasons to provide "free cooling" — using cool outdoor air to reduce mechanical refrigeration load and save energy — but during winter it is deliberately set to the minimum outdoor-air position required by ventilation codes (typically 10–20%). This minimum setting satisfies indoor air quality and occupant ventilation requirements while limiting excessive heating energy use.

ESTIMATING THE WINTER MAKEUP-AIR CONTRIBUTION

To estimate the winter makeup-air contribution from the HVAC economizer:

- 1 Multiply total HVAC tonnage by approximately 400 CFM per ton to approximate total supply airflow. This 400 CFM/ton figure is a widely used rule of thumb — actual airflow varies roughly 350–450 CFM/ton depending on equipment design, so treat it as a starting estimate rather than a nameplate value.
- 2 Apply the minimum economizer outdoor-air percentage: $\text{Total tons} \times 400 \text{ CFM/ton} \times \text{economizer setting}$ (example: 20% — $100 \text{ tons} \times 400 \text{ CFM/ton} \times 0.20 = 8,000 \text{ CFM}$ of outside air).

This winter minimum value is included when determining the governing makeup-air CFM for humidification load calculations (see Governing Airflow, Section 02, and Required Building Data, Section 04).

HANDLING MULTIPLE HVAC UNITS

Most facilities of any size run several rooftop or air-handling units rather than one central system. Calculate each unit's winter outside-air contribution separately, using that unit's own tonnage and economizer setting, then sum the results — units are rarely sized or set identically. A plant with three 50-ton RTUs at 15%, 20%, and 20% settings, for example, contributes $3,000 + 4,000 + 4,000 = 11,000$ CFM combined, not a single blended calculation across all 150 tons.

WHERE TO FIND ACTUAL VALUES

- **Total tonnage:** equipment nameplates, mechanical schedules on as-built drawings, or the facility's TAB (test-and-balance) report.
- **Economizer minimum-position setting:** the building automation system (BAS/EMS) setpoint or trend log, the controls contractor's sequence of operations, or the mechanical engineer of record's design documents.



APPENDIX REFERENCE

APPENDIX C CONTINUED

- When none of these are available, 20% is a reasonable default per typical ASHRAE 62.1 minimum ventilation rates for light-industrial occupancies — but verify against actual equipment where the load calculation is tight to the equipment's rated capacity.

CAUTION — FREEZE-PROTECTION LOCKOUTS

Many economizers include a low-temperature lockout that closes outdoor-air dampers further (sometimes fully) below a set outdoor temperature — often in the 0–10°F range — to protect coils from freezing. Because this guide's load calculation uses the coldest design-day temperature (Section 04), that is precisely the condition under which a lockout is most likely to be active. If your site's economizer locks out at or above its stated outdoor design temperature, the actual winter makeup-air contribution on the coldest days may be lower than the nameplate-and-setting calculation above suggests. Verify the lockout temperature against your outdoor design temperature, and where the two are close, cross-check using the ACH-basis Formula #2 (Section 06) rather than relying on the economizer figure alone.



APPENDIX REFERENCE

APPENDIX D

PROCESS EXHAUST — VOC/SOLVENT CONSIDERATIONS & CODE COMPLIANCE

PROCESS EXHAUST GUIDANCE

Section 04's process-exhaust guidance and Section 07's worked example both split process exhaust into two streams — fully-exhausted process air (press/laminator exhaust) and recirculating process exhaust (die-cutter/slitter exhaust with a 10–20% loss factor). This appendix explains why that split exists and why it matters for sizing accuracy, in more depth than Section 04's illustrative example allows

WHY PRESS AND LAMINATOR EXHAUST IS TYPICALLY NOT RECIRCULATED

Woodworking dust collection filters particulate and is commonly designed to return the bulk of that filtered air indoors during winter, which is why Section 04's 10–20% loss treatment works well for particulate-generating equipment such as die cutters and slitters in this guide's process. Press and laminator exhaust is a different kind of stream: where flexographic or offset printing uses solvent-based inks, coatings, or adhesives, the exhaust carries volatile organic compounds (VOCs) and elevated heat, not just particulate. Recirculating VOC-laden air back into the occupied shop floor is generally avoided, both for worker air-quality reasons and because most air permits do not allow it — this exhaust is typically sent outdoors, and in many jurisdictions it must first pass through a regenerative thermal oxidizer (RTO) or comparable VOC-destruction equipment before release.

The practical consequence for load calculations: this fully-exhausted stream contributes 100% of its CFM to the governing exhaust total, with no loss-factor adjustment, because none of it returns to offset the building's air balance the way recirculating exhaust does. Treating it with the same 10–20% loss assumption used for particulate systems will understate total exhaust CFM — and per the governing-airflow rule (Section 02, Appendix A), understating exhaust can flip which side (ExA vs. MuA) actually governs, silently undersizing the FanMist system.

WHERE TO FIND ACTUAL VOC EXHAUST FIGURES

- Water-based or UV-cured ink and coating lines typically generate little to no VOC exhaust and may legitimately follow the recirculating-exhaust treatment in Section 04 — confirm ink/coating chemistry before assuming a fully-exhausted stream is required.
- For solvent-based lines, the facility's air permit (state VOC/air-quality permit, or Title V permit for larger sources) will list permitted exhaust points and their rated CFM — this is usually the most reliable source, since it reflects what the equipment is legally required to exhaust.
- The environmental or EHS (health & safety) team, or the press/laminator manufacturer's equipment specifications, can typically confirm whether a given line's exhaust is recirculating or fully exhausted.



APPENDIX REFERENCE

APPENDIX D CONTINUED

- If an RTO or other VOC-abatement system is present, its rated inlet CFM is a reliable proxy for the fully-exhausted process air total, since abatement systems are sized to the exhaust stream they treat.

PRACTICAL TAKEAWAY

Don't assume all process exhaust in a paper, print, or label facility behaves like woodworking dust collection. Separate the fully-exhausted (VOC/heat-laden, no loss factor) streams from the recirculating (filtered, 10–20% loss) streams before totaling exhaust CFM for the governing-airflow calculation — and when in doubt, verify against the facility's actual air permit rather than assuming a loss percentage.



APPENDIX REFERENCE

APPENDIX E

ADDITIONAL REFERENCE NOTES

1. UNIT CONVERSION QUICK REFERENCE

CONVERSION	VALUE
Grains to pounds	7,000 grains = 1 lb of water
Water weight	8.34 lbs per gallon
gpm to lbs/hr	1 gpm = 500 lbs/hr at 1000 psi ($8.34 \times 60 = 500.4$)
CFM to ft ³ /hr	CFM x 60
°F to °C	$(^{\circ}\text{F} - 32) \times 5 \div 9$

2. WHERE THE 111.16 LB/HR/FAN RATING COMES FROM

Each 27" mist ring carries 14 nozzle ports; at the standard 7.94 lb/hr Blue Band orifice, $14 \times 7.94 = 111.16$ lb/hr per fan — the figure used throughout Section 08's equipment sizing. This is specific to that nozzle/mist-ring combination. Swapping to a different orifice size or nozzle count changes the per-fan rating accordingly — always re-derive fan output from the actual nozzle specification installed rather than assuming 111.16 lb/hr/fan universally.

3. SAFETY MARGIN PHILOSOPHY

The 15% margin used throughout this guide (Section 02, Section 06) accounts for colder-than-design temperatures and minor operating variation — it is a baseline, not a ceiling. Shops with frequent large door openings (shipping/receiving traffic), mixed operations (a rough mill alongside a finishing or assembly area), or planned future production increases may reasonably size to a larger margin. Where that applies, increase Column Q's multiplier in the sizing spreadsheet (Section 08, Part 1 of 3) deliberately, as a documented decision — rather than defaulting to 15% without considering whether the specific facility warrants more.

4. SECONDARY FACTORS REMINDER

The Practical Method used throughout this guide intentionally omits product regain, process vapors, and people (Section 07's Comprehensive Method covers all three: dry incoming paper rolls, sheets, or other substrate stock absorbing moisture as it reaches EMC, water vapor released during ink/coating drying and laminating, and occupant respiration). These factors are typically small relative to the ventilation load and often partially offset one another — but for high-throughput shops or tight tolerance targets, revisit Section 07 for the fuller calculation before finalizing equipment selection.

CONTINUED



APPENDIX REFERENCE

APPENDIX E CONTINUED

5. GLOSSARY OF ABBREVIATIONS

TERM	MEANING	TERM	MEANING
ACH	Air Changes per Hour	MuA	Makeup-Air (CFM)
CFM	Cubic Feet per Minute	TMC	Target Moisture Content (gr/ft ³)
EMC	Equilibrium Moisture Content	GD	Grains Difference (gr/ft ³)
RH	Relative Humidity	FSC	Final System Capacity (lbs/hr)
ExA	Exhaust-Air (CFM)	GPM	Gallons per Minute

INDUSTRY STANDARDS & REFERENCES

The ventilation principles referenced throughout this guide — including minimum outdoor-air requirements and economizer minimum-position settings — are consistent with widely recognized industry guidance, including ASHRAE Standard 62.1 (Ventilation for Acceptable Indoor Air Quality). Building-specific ventilation rates, economizer settings, and code requirements vary by jurisdiction and application; consult your mechanical engineer or local code authority to confirm the specific requirements applicable to your facility.