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Paper Machine and Room Ventilation Systems Guidelines

Scope

This Technical Information Paper provides an overview of principles and guidelines for designing and optimizing paper machine process air systems and room ventilation systems.

Safety precautions

Normal safety precautions should be taken when working around operating machinery, hot surfaces, and steam systems. Safe work practices should always be followed during evaluation, inspection and maintenance of these systems.

Application note

This Technical Information Paper provides general descriptions and guidelines for designing air systems and estimating airflow requirements for paper machine and machine room ventilation systems. Engineers with experience in paper machine and machine room air handling should be consulted for specific design work and to address specific operating problems.

Calculations are presented in both Imperial and SI units. Refer to Table 1 for Imperial to SI conversions. Two sample calculations are included at end of this TIP: one for a linerboard paper machine and one for a copy grade paper machine.

It should be noted that the cost of following these principles may appear high. However, the risk of not following these principles is far greater. Infrastructure repairs, higher operating costs, reduced machine room comfort, and lower production efficiency often result from deficiencies in the air and ventilation system design.

Ventilation principles

Purpose and benefits

Ventilation air is used to improve drying uniformity and capacity, improve the working environment, reduce maintenance of roof and building equipment, reduce product contamination, and extend process equipment life. Ventilation air represents a significant resource in the production of paper and board. The amount of air required to produce a ton of paper can be 75 tons or more, depending on the grade of paper.

Ventilation air serves two primary purposes:

- contain and remove water vapor, heat, and dust
- replace air removed in the drying process and by vacuum systems

Poorly designed, operated or maintained ventilation systems can cause unsafe conditions and impact production. A well-ventilated building has the following attributes:

- good visibility (no fog) in the production areas
- no condensation on wall and ceiling surfaces
- comfortable working conditions in operating areas
- no stagnant airflow areas
- controlled airflows in and out of the building for efficient paper drying and sheet handling
- energy efficiency

Contaminants

The three major contaminants present in a paper machine environment are water vapor, heat, and dust.

Water vapor

Uncontained water vapor will spread throughout the building primarily by convective airflows and, to a lesser degree, by diffusion.

Fog and condensation occur when the water partial pressure exceeds the saturation partial pressure at that same temperature. The local temperature is a function of the heat gain or loss.

Heat

Papermaking is an energy intensive process. Typical process heat loads are listed as follows:

Area/Source	Floor Level	Heat	
		Btu/ton	kW-h/tonne
Stock Preparation			
- Refiners Bleached Board:	Operating	73 900	23.8
Corrugating:		37 000	11.9
Fine Paper:		88 000	28.6
Linerboard:		51 700	16.7
Publication:		59 100	19.1
- Cleaners (based on footprint)	Operating	1 000 Btu/h/ft^2	3.15 kW/m^2
- Pumps & Piping	Ground	20 000	6.5
Former & Press			
- Vacuum System	Ground	39 500	12.7
- Pumps & Piping	Ground	75 000	24.2
PM Drive			
- Forming & Press	Operating	51 600	16.7
- Main Dryer	Operating	18 500	6.0
- Size Press	Operating	3 200	1.0
- After Dryer	Operating	6 400	2.1
- Calender	Operating	14 500	4.7
- Coater	Operating	27 100	8.8
- Reel	Operating	8 600	2.8
- Winder	Operating	44 400	14.3

Table 1.

Dust

Airborne dust in high concentrations is an occupational health concern and can become a fuel source for fires.

The major sources of dust come from poor broke handling practices, sheet shedding doctor blades, creping doctor blades, and winder slitters. Sheet over-drying increases dusting.

Air lanes, air nozzles, and air hoses should be avoided in cleaning dusty areas because they can cause dust to become airborne.

Dust prevention should be the primary focus, with cleaning and collection being the last steps.

Recommended levels

Minimum and maximum levels for temperature, humidity, and dust are recommended based on location within the machine room.

[Note: The values listed for maximum apply when the outdoor ambient temperature is above the listed minimum temperature value].

Variable	Location	Minimum	Maximum (above outdoor ambient)	Remarks
Temperature °F	Ground Floor	65	≤ 10	
	Operating Floor – tending, wet end	75	≤ 5	
	Operating Floor – tending, elsewhere	65	≤ 5	
	Operating Floor – drive side	65	≤ 10	
	Mezzanine	-	≤ 20	
	Underside Roof	-	≤ 25	
Humidity grains H_2O/lbDA	Ground and Operating Floors	-	≤ 50	No fog or condensation
	Mezzanine	-	≤ 100	
	Underside Roof	-	≤ 150	
Dust mg/m^3	Total (all airborne particles)	-	15 (including ambient)	
	Respirable (airborne particles <10 µm)	-	5 (including ambient)	

Table 2.

Factors affecting ventilation performance

The amount of ventilation air required is a function of a number of factors, including the following:

Factor	Impact on Building Ventilation
Production Rate	• Higher production rates have higher evaporation rates and, correspondingly, require more air
Grade of Paper	• Lighter grades are more susceptible to air drafts, requiring lower air velocities
Machine Speed	• Higher heat and mass transfer with increased machine speed
Type of Former	• Top wire and gap formers require higher exhaust rates than fourdrinier formers
Stock Temperature	• Increase mass transfer rate with increase in temperature
Type and Condition of Dryer Hood	• Open hood requires more exhaust air than a closed hood
Climate	• Colder climates require higher building air balance • Warmer climates require higher ventilation rates during the summer
Building Geometry	• Air follows the path of least resistance leading to short-circuiting of air
Equipment Layout	• Multiple machines in the same building are more difficult to ventilate than single-machine rooms
Building Construction	• Building pressure is dependent on building tightness • Increased risk of condensation with less wall and roof insulation

Table 3.

Air movement

Building air movement is a function of air pressure, momentum, and density.

Air discharged from a one-foot diameter opening travels 30-feet (30-diameters) before being reduced to ten percent of its initial velocity.

Stack effect causes denser cool and dry air to enter the building at the ground floor level as warm, moist (less dense) air rises to the underside of the roof, resulting in a vertical pressure difference with respect to the building exterior. With equal supply and exhaust flows, a neutral pressure level, or "null point", would occur at or below the mezzanine floor level. Above the null point, air exfiltrates out (positive pressure) of the building and conversely infiltrates (negative pressure) into the building below the null point.

Dryer section hoods are greatly affected by stack effect because the air temperature is higher inside the hood. Increasing the hood exhaust or reducing the supply flow rates raises the null point. Decreasing exhaust or increasing supply flows lowers the null point. Opening doors below the null point introduces more air into the enclosure, which is comparable to increasing the supply flow and in turn lowering the null point. Opening a felt-loading door, above the null point, is equivalent to increasing the exhaust flow rate and raising the null point, even though hot and humid air would be "dumped" into the machine room.

Ventilation methods (3,4)

Four primary methods of ventilation are: mixed ventilation (dilution), unidirectional ventilation (piston airflow), displacement ventilation (passive thermal displacement), and localized ventilation (spot cooling). Displacement ventilation is the recommended method for paper machine building ventilation, with local ventilation applied to isolated areas.

General guidelines

1. Capture heat and water vapor as close to its source as possible because it will require less exhaust airflow than diluting it later.
2. Direct all exhaust to atmosphere outside of the machine room, after reclaiming its heat for processes or building supply air heating.
3. Minimize the amount of air exhausted to reduce energy costs.
4. Move air from areas of low heat and water vapor concentrations to areas of high heat and water vapor concentrations: dry-end-to-wet-end and tending-side-to-drive-side. Introduce air into the building such that it removes as much heat and water vapor as practical before being exhausted.
5. A balance between supply and exhaust systems is required for any ventilation system to function as designed.
6. General ventilation should primarily be used for comfort control, with water vapor control usually a secondary consideration. Dilution ventilation reduces overall water vapor concentration and temperature.
7. Use make-up air for personnel ventilation only.
8. Supply air should have sufficient volume and heat to prevent condensate and fog from forming.
9. Displace heat and water vapor from operating personnel zones with large quantities of make-up air. Distribute air directly to work zone (below 10 feet) to provide effective dilution ventilation. Avoid high velocity discharges, which entrain warm and humid air streams.
10. Care should be taken to avoid unintentional short-circuiting.
11. The exhaust discharge, whether local or general, should be directed so as to reduce the possibility of reentry. Exhaust discharges should be located away from windows and air intakes.
12. Avoid locating ventilation ducts in the upper building levels unless insulated.
13. Perform regular maintenance on ventilation equipment and systems to ensure optimum performance.
14. Test ventilation systems periodically to ensure they continue to operate as designed.