Signs You Need Make-up Air & Air Make-up Operating Costs

Introduction

The lack of make-up air in a building can cause serious problems. Many times the problems are not even recognized and show themselves in ways that most people do not think about. A properly designed and installed ventilation system provides environmental control by avoiding negative pressure. Uncontrolled infiltration of air through window sashes, doors and walls leads to many undesired results. In this document we will discuss a few of these problems and inform you about the cost of make-up air.

Signs That You Need Make-up Air

Poor paint finishing due to dust, moisture or fumes. Exhaust fans will compete with each other for the available air. They are going to pull air from anywhere they can. Paint booth fans may lose out in the competition causing the paint to retain moisture and collect dust that is not removed by the exhaust fans.

Walls have moisture being pulled through. This shows that your plant is under negative pressure. Cement walls have small cracks that allow water to penetrate. Fans pull from every place air can get through. This includes walls. When fans pull air through walls, water from rain and other outdoor sources will also be pulled through. This will cause firring strips to rot, ruin wall coverings and paint jobs.

Smoke, haze and dust floating in the air. As you look across the factory is it hazy? You should be able to see clearly from one end of your factory to the other without the view being blocked by haze and smoke. If the area clears when a window or door is opened, it is starved for air. This indicates that the exhaust fans are competing for air. Welding, molding, metal cutting or many other processes can generate fumes that need to be exhausted or the factory could become hazy.

Stacks and exhaust fans take up a large portion of your roof. If this is the case, you are a prime candidate for make-up air. The number of stacks and exhaust fans on the roof is an easy way to gauge the amount of make-up air needed. The area of inlet air should be equal to or greater than the area of exhaust air.

The hoods seem to have a downdraft rather than the normal updraft. The fumes from hoods are supposed to go up the hoods, but if the fan is starved for air the fumes will be found in the plant. This is also true for gas hot water heaters, boilers, furnaces and unit heaters or any other process that has a flue on it.

Fan motors also work harder when they are required. When a fan attempts to move air that is not there, it causes the load to rise. This causes the insulation to break down and shorten life. Motors should last 6 or more years. When every exhaust fan in the plant is fighting for the same air, all the motors are going to have decreased life.

When walking through the plant, odors seem to linger. Weld fumes, paint fumes and dip tanks all need to be exhausted. These fumes can cause undesirable mixtures of odors that linger and cause burning, watery eyes, sore throats or sinus trouble. This contributes to an unsafe environment and poor indoor air quality.

Locker room, bathroom and other odors seem to creep through the plant and office. People's clothes smell like the production line. Processes like oil mist, boilers, roasting ovens and paint booths have odors. All these aromas require ventilation. If the ventilators cannot provide the required number of air changes in the room, your plant is short of air.

Doors that are hard to open or doors that will not shut on their own are a sure sign that the plant is short of air. Inward swinging doors are easy to open and hard to close. Drafts through the door seals and knobs that are hard to turn add to the problem. Outward swinging doors are hard to open and "slam" shut, damaging seals and wearing hinges. Hydraulic door closer settings are set high to pull doors closed without slamming.

Shutters on the exhaust fans are not 100% open. Automatic or balanced shutters are not open. These shutters should be 100% open when the exhaust fans are running. If the exhaust fan is not getting enough air, the shutter will not open all the way. The shutters should gradually close when the fan is turned off. They should not slam shut.

Steel near the fume hoods is corroding due to fumes that should be exhausted. Many corrosive liquids require their own hood. Typically the hood is a stainless steel and will not deteriorate from the fumes. If the air is not going up the hood and fumes are being pulled through another exhaust fan that is not designed to handle the corrosive atmosphere, the fan and any nearby steel will also corrode and decrease the life of the unprotected equipment.

Cracks under the doors collect leaves, dirt or gum wrappers. The threshold of the door will collect a substantial amount of debris during the day due to the exhaust fans trying to grab air from anywhere they can get it. Part of grabbing the air will be the collection dirt and trash. Table 1 shows the velocity (ft/min) and the corresponding negative pressure associated with an opening in the building.

Table 1. Negative pressures and corresponding velocities

NEGATIVE PRESSURE (IN. W.G.)	VELOCITY (FPM)
0.004	150
0.008	215
0.010	240
0.014	285
0.016	300
0.018	320
0.020	340
0.025	380
0.030	415
0.040	480
0.050	540
0.060	590
0.080	680
0.100	760
0.150	930
0.200	1080
0.250	1200
0.300	1310
0.400	1520
0.500	1700
0.600	1860

Cold walls. The walls should not be cold. The wall can act as an insulator if the air is balanced. Insulation will prevent some drafts, but no insulation will prevent all the air from coming through. With negative pressure, however, the drafts through the wall will be cold regardless of the amount of insulation. These cold drafts will cause absenteeism and help spread colds and illness throughout the building. People will constantly fight over the thermostat setting.

Figure 1. Hot and cold zones

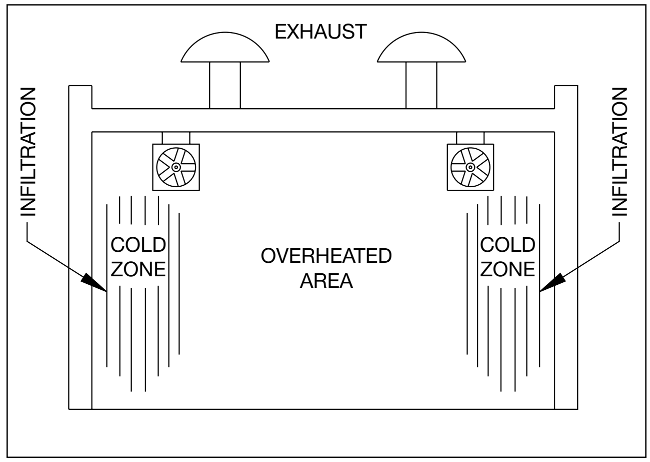

Figure 1 shows how cold zones will occur along walls and overheated zones will show in the middle of the building.

Fuel will be conserved with proper ventilation. Without make-up air, cold conditions near the building perimeter and overheated areas in the middle of the building lead to installation of more inefficient unit heaters. These heaters work overtime to heat the air, which in turn gets pulled to center of the building thus adding to the overheating problem.

Pilot lights go out and the area smells of flue gases. The flue gases from the unit heaters must go up. When makeup air is needed, these gases do not go up the flue but back into the building. Unit heaters are not necessary with the proper makeup air units. The heat for the plant will come from the makeup air unit and the unit heaters will not run.

Table 2 gives examples of adverse conditions associated with negative pressure in buildings.

Table 2. Negative pressures and conditions associated to them

NEGATIVE PRESSURE (IN. W.G.)	ADVERSE CONDITIONS
0.01 to 0.02	WORKER DRAFT COMPLAINTS. High velocity drafts through doors and windows.
0.01 to 0.05	NATURAL DRAFT STACKS INEFFECTIVE. Ventilation through roof exhaust ventilators, flow through stacks with natural draft greatly reduced.
0.02 to 0.05	CARBON MONOXIDE HAZARD. Backdrafting will take place in hot water heaters, unit heaters, furnaces and other combustion equipment not provided with induced draft.
0.03 to 0.10	GENERAL MECHANICAL VENTILATION REDUCED. Air flows in propeller fans and low pressure supply and exhaust systems.
0.05 to 0.10	DOORS DIFFICULT TO OPEN. Serious injury may result from non-checked, slamming doors.
0.10 to 0.25	LOCAL EXHAUST VENTILATION IMPAIRED. Centrifugal fan exhaust flow reduced.

How Much Air Do You Need?

The amount of air required for positive pressure is between 5 and 10 percent more than the air exhausted. An inventory of the exhaust should be taken. This includes exhaust fans, process systems, and combustion processes. Once this number is determined, projections should be made for future plant expansions and process changes. It is more economical to account for these changes and purchase a larger unit sized for current and future applications. Increasing the speed of a unit in the future is more economical than purchasing a second unit at a later date.

Even if the building is a "tight" building, there are exhaust fans in the restrooms, flue gas from the hot water heater, boilers and kitchen ventilators. This air needs to be replaced. These buildings can leak enough air for 1.5 to 2 air volume changes per hour. In this case, the volume of air should be calculated according to the building volume as follows:

$$V_a = V_b \div E$$

Where: V_a = required air volume (cubic feet)
V_b = building volume (cubic feet)
E = exfiltration factor
E = 40 for 1½ changes per hour
E = 30 for 2 changes per hour
E = 20 for 3 changes per hour

E = 40 is recommended for most calculations. When selecting the proper E factor, the building construction and the environment of the workers should be taken into account. Keep in mind that more air exchanges per hour will also increase operation costs.

There are applications where a negative condition is desired. This condition must be properly controlled to operate effectively. An example is where contaminates must be prevented from escaping to the environment and must go through a filtration process prior to being ventilated to the atmosphere. Typically a negative condition is achieved when the exhaust is no more than 5 percent more than the makeup air.

Estimating Fuel Cost

Now that you know you need make-up air, how much more is it going to cost? Typically the installation of an air make-up unit will cost no more than 20% more on your fuel bill. If your plant is heated and you have exhaust fans you are paying to heat the air but not receiving the benefit of the heated air. Many times, the cost of operating the air make-up unit is less than the operation of the unit heaters. Also, the exhaust fans are getting the air from somewhere if there are no air make-up units.

The calculation below shows an overall cost of operating an air make-up unit. The example that follows illustrates that the increase in operating cost is no more than 20%.

Calculating yearly cost:

C1 = Yearly Cost = 0.154 (Q) (dg) (T) (c) ÷ q

Where: Q = air flow rate
dg = annual degree days (Table 3)
T = operating time, hours/week
c = cost of fuel, $/unit
q = available heat per unit of fuel

Table 3. Heating degree days for a discharge temperature of 68 degrees

STATE	CITY	DEGREE DAYS
New York	Albany	7750
	New York	5606
Massachusetts	Boston	6458
Illinois	Chicago	6905
Ohio	Cleveland	7313
Michigan	Detroit	7100
Minnesota	Minneapolis	9269
Pennsylvania	Philadelphia	5886
	Pittsburgh	6833
Missouri	St. Louis	5523
District of Columbia	Washington	4929

Example:
Find the yearly cost of a 25,000 cfm air makeup unit in Cleveland, Ohio operating 40 hours per week.

Using the formula:

C1 = Yearly Cost = 0.154 (Q) (dg) (T) (c) ÷ q

Where: Q = 25,000 cu. ft/min
dg = 7313
T = 40 hr/wk
c = $0.50 per therm (1 therm = 100,000 btu/hr)
q = 100,000 btu/hr
C1 = 0.154 (25,000 cu. ft/min) (7313) (40 hr/wk) x ($0.50 therm) ÷ (100,000 btu/hr)
= $5,631 per year (40 hrs per week)

The $5,631 per year looks like a lot of money. We will need to take a deduction for 96 percent efficiency although direct fired air make-up units are very close to 100 percent efficient. At 96% efficient the cost would be $5,866 per year. Now look at the fact that the air being exhausted was being heated through cracks around doors, windows and unit heaters. Without the air make-up we were exhausting 20,000 cfm. Now with the air make-up we are exhausting 22,500 cfm making the building a slight positive.

Using the formula:

C1 = Yearly Cost = 0.154 (Q) (dg) (T) (c) ÷ q

Where: Q = 20,000 cu. ft/min
dg = 7313
T = 40 hr/wk
c = $0.50 per therm (1 therm = 100,000 btu/hr)
q = 100,000 btu/hr
C1 = 0.154 (20,000 cu. ft/min) (7313) (40 hr/wk) x ($0.50 therm) ÷ (100,000 btu/hr)
= $4,505 per year (40 hrs per week)
If the unit heaters were 100 percent efficient and before the air make-up.

Unit heaters are only around 80 percent efficient. The true cost is now $4,505 ÷ 0.8 = $5,631 for the building without the make-up air unit. This is only a difference of $235 or approximately 4 percent more per year. This is a very typical example of an installation of an air make-up unit.

Makeup air is a very important element of any building's indoor air quality. The health of workers depends on good clean air. As exhaust fans are added and processes are changed the amount of makeup air must be monitored and maintained to keep the proper number of air exchanges per hour.