

## SPECIAL POINTS OF INTEREST REGARDING UTAB:

- Celebrating 32 years in business.
- 2007 was UTAB's most successful year.
- Over 25% of our TAB technicians are certified Test and Balance Engineers.



Figure 1a. Plume impact on taller downwind building.



Figure 1b. Plume impact on taller upwind building.

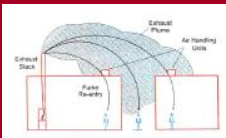


Figure 2. Illustration of potential air quality problems due to laboratory emissions.



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The design of exhaust stacks and air intakes needs careful consideration. Public concern has increased regarding air pollution in general. In addition, adverse exposure to air pollutants in the workplace can affect employee health and productivity. In some cases, releases of toxic pollutants may lead to litigation.

Some challenges to specifying a good stack design include the existing building environment, aesthetics, building design issues, chemical use, source types, local meteorology and topography. For example, if a new laboratory building that is being designed is shorter than surrounding buildings, it is difficult to design a stack so the exhaust will not impact neighboring buildings.

The effect of a taller downwind or upwind building is illustrated in Figure 1. The plume hits the face of the taller building when it is downwind and, when it is upwind, the wake cavity region of the taller building traps the exhaust from the shorter building. In either case, the plume impacts the face of the taller building.

Figure 2 further illustrates problems that can be created by poor stack design. Fumes from the exhaust may reenter the building, enter adjacent buildings, or impact pedestrians at unacceptable concentration levels. To avoid adverse air quality, taller stacks, higher volume flows and/or

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optimum locations on the roof may be necessary.

In most cases, laboratory stack design is a balance between various constraints and obtaining adequate air quality at surrounding sensitive locations (air intakes, plazas, operable windows, etc.) The lowest possible stack height is designed for aesthetics, while exit momentum (exit velocity and volume flow rate) is limited by capital and energy costs, noise, and vibration. To determine the optimal exhaust design, predictions of expected concentrations of exhausted pollutants at sensitive locations are needed to compare against health limits and odor thresholds. These predictions can be accomplished with varying degrees of accuracy using three different methods: 1) a full-scale *field program*; 2) a *mathematical modeling* study; or 3) a reduced-scale study conducted within an atmospheric-boundary-layer *wind tunnel*. A full-scale field program may provide the most accurate prediction of concentration levels but can be expensive and time consuming. In addition, it is impossible to evaluate designs before construction is completed.

*Numerical models* can be divided into two categories, *analytical* models and *computational fluid dynamics* (CFD) models. Analytical models assume a simplified building configuration and provide concentration estimates based on assumed concentration distributions, i.e. Gaussian. These models do not consider site-specific geometries that may substantially alter plume behavior.

CFD models attempt to resolve the plume transport by solving the Navier-Stokes equations at finite grid locations. *Wind-tunnel modeling*, on the other hand, is much like conducting a field experiment when the concentrations are measured in a simulated flow at the points of interest over a scale model of the buildings under evaluation.

This article describes a quantitative approach to accurately evaluate exhaust and intake designs to ensure acceptable air quality inside and around buildings. Also described for background purposes are various exhaust and intake design issues such as applicable standards and recommendations, analytical methods, plume rise, architectural screens, and entrained air exhaust stacks.

### Exhaust/Intake Design Issues

#### Applicable Standards and Recommendations

Several organizations have published standards or recommendations regarding laboratory exhaust stack design as summarized here.

1. Maintain a minimum stack height of 10' to protect rooftop workers.
2. Locate intakes away from sources of outdoor contamination such as mobile traffic, kitchen exhaust, streets, cooling towers, emergency generators and plumbing vents.
3. Do not locate air intakes within the same architectural screen enclosure as contaminated exhaust outlets.

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# Specifying Exhaust and Intake Systems

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4. Locate the air intake at the base of a relatively tall stack or tight cluster of stacks, if this location is not adversely affected by exhaust from nearby buildings. Intakes should not be located near the base of highly toxic stacks due to potential fan leakage.
5. Avoid locating intakes near vehicle loading zones. Canopies over loading docks do not prevent hot vehicle exhaust from rising up to intakes above the canopy.
6. Use High Efficiency Particulate Air (HEPA) filters or Ultra Violet Germicidal Irradiation (UVGI) systems of similar efficiency in isolation room exhaust streams.
7. Combine several exhaust streams internally to dilute intermittent bursts of contamination from a single source, as well as producing an exhaust with greater plume rise. Additional air volume may also be added to the exhaust at the fan to achieve the same end.
8. Group separate stacks together (where separate exhaust systems are mandated) in a tight cluster to take advantage of the increased plume rise from the resulting combined jet. Note that all the exhausts must operate continuously to take full advantage of the combined jet.
9. Avoid rain caps or other devices that limit plume rise on exhaust stacks. Conical rain caps often do not exclude rain, because rain does not fall straight down. Alternate design options are provided in Chapter 32 of the *ASHRAE Handbook—HVAC Applications*.
10. Consider the adverse effect of architectural screens. A solid screen effectively decreases the stack height by 80%.

## Analytical Methods

Chapter 43 of the *ASHRAE Handbook—HVAC Applications* discusses exhaust stack design in some detail. The chapter contains

two primary types of information regarding stack design: 1) a geometric method of determining stack height; and 2) mathematical equations for predicting rooftop concentrations. In the geometric method, the recommended stack height is that for which the bottom edge of the exhaust plume will be above various recirculating and high turbulence zones. In general, this method is entirely inadequate for exhaust streams that contain toxic or odorous material, as it does not provide an estimated concentration at an air intake or other sensitive location. Hence, no information on the adequacy of the stack to avoid concentrations in excess of health or odor limits is provided. The analytical equations tend to be conservative for an isolated building or one that is significantly taller than the surrounding buildings and for air intakes on the roof level. Also, they are not appropriate for complex building shapes or when buildings of similar or taller height are nearby.

Using the ASHRAE dispersion equations and a 400  $\mu\text{g}/\text{m}^3$  per g/s ASHRAE design criterion, a graph can be generated giving the minimum recommended stack height to ensure that the design criterion is met.

## Plume Rise and Dispersion

Adequate plume rise is important to ensure that the exhaust escapes the high turbulence and recirculation zones on the building roof. Plume rise increases with increased exit momentum and decreases with increased wind speed. Reducing the diameter to increase exit velocity will enhance plume rise. However, a high exit velocity in itself does not guarantee adequate plume rise since the volume flow rate, and thus momentum, are factors as well. Plume rise is also degraded by increased atmospheric turbulence since the vertical momentum of the exhaust jet is more quickly diluted.

If the ratio of exit velocity to approach wind speed is too low, the plume can be

pulled downwards into the wake of the stack structure creating negative plume rise, a condition referred to as stack-tip-downwash. This downwash defeats some of the effect of a taller stack and can lead to high concentrations at the building surface. A rule of thumb for avoiding stack-tip-downwash is to have the exit velocity be at least 1.5 times the wind speed at the top of the stack. The wind speed exceeded 1% of the time is commonly used for estimating the minimum exit velocity required to avoid stack-tip-downwash. ASHRAE provides a listing of 1% wind speeds for various metropolitan areas around the world.

For a given stack design and receptor location, there is a “critical wind speed” causing the maximum concentration. Wind speeds lower than this critical speed result in greater plume rise; higher wind speeds provide more dilution due to the greater volume of air passing the exhaust stack. The critical wind speed increases with exit velocity, exhaust volume flow rate and stack height.

## Architectural Screens

Architects or building owners often want to hide their exhaust stacks using screening material. An ASHRAE funded research study was conducted to evaluate the effect of architectural screens on rooftop concentration levels. The study found that screens can significantly increase concentrations on the roof and, in effect, reduce the effective stack height. The study evaluated various enclosure sizes and heights but found that the main parameter affecting rooftop dispersion was the screen porosity. The results of the study provide a quantitative relationship between screen porosity and stack height.

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# WWW...Walter's Winning Words



With no end to the rising gas prices in sight, we all need to be aware of our fuel consumption. Some things to consider as we face tightening budgets on both personal and business levels:

- Combine trips whenever possible.
- Carpool when practical or consider meeting midway and continuing in one vehicle.
- Don't drive aggressively! Accelerate slowly and keep your

speeds down. Your "manners" behind the wheel directly affect you MPG.

- Keep tires properly inflated and vehicle maintained.
- And of course the obvious, watch for the lowest price at the pumps.

Try to plan when to buy gas and do not just drive until the tank is empty. If you notice it cheaper by the job site than near home, fill the tank before heading home in the

afternoon (or vice versa).

We do not want to have to start limiting the usage of company vehicles so in order to keep this from happening we need to work together to weather this economic pinch on our cash flow.

- In the words of Henry Ford:  
Coming together is a beginning.  
Keeping together is progress.  
Working together is success.

*Sometimes one smile means more than a dozen roses.*  
—Promise Yogurt

## Management Tips

**Know what stresses you most...YOU!!** Get your feelings out. Write them out and describe each situation. Before you can conquer your stress you must know what is stressing you.

**Say no.** Focus on your own goals, not your spouse's or parent's. Before you take on another responsibility just say "I will check my schedule/to-do list and let you know if I can help you out." If it does not fit in there simply say thank you

but I just cannot.

**Learn to relax.** Work hard but know when to take time off to be with the family, go for a walk, or read a book.

**Eat healthy.** Eat less junk food and more fruit and vegetables for an amazing overall lowering of stress levels. We can actually lower the amount of bad stress hormone, Cortisol, by taking vitamins.

**Keep laughing.** Keep a sense of humor. Studies show a good attitude helps lower cancer rates, makes surgery more effective and keeps a relationship together through hard times.

**Ask yourself WHY.** Why are you doing this? The more you understand why your doing what you are doing the less stress you will have. If you cannot come up with a good reason, then stop doing it.

**Stay active.** Exercise is a great way to relieve tension and gives you a great break. A healthy body makes a happy body.

**Organize and Prioritize.** Do the worst and hardest tasks first. Keep a to-do list and calendar with you at all times.

Stress can overwhelm you and these eight simple steps can make a difference.



UTAB had two golf teams participate in the Nashville ASHRAE Golf Tournament on April 18th. Congratulations to the '3 Jacks and a Jill' team (Brian Harrington, Derrick Harrington, Walter McCauley and Kathy Ogles) for first place in the 2nd flight.

UTAB also participated in the TAHGCC Danny Burnette Golf Classic in Knoxville on April 25th. Congratulations to the team of Randy Britt, David McCauley, Walter McCauley and Stewart Moen for first place in the 3rd flight.

Happy Anniversary!  
Delta & Austin Carl





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**"We do it right!"**

**United Testing and Balancing, Inc. began as an independent test and balance agency in 1976 and maintains its corporate office in Nashville, Tennessee. Since 1976, UTAB has tested and balanced a variety of projects. We are also qualified to certify cooling tower performances and measure sound and vibration. In conjunction, Phase I Indoor Air Quality (IAQ) investigations and IAQ Assurance Monitoring of buildings for owners and property managers are included in our scope of services.**

**Old fashioned values with modern technology are combined to assure project success.**



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