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▸ THE PRACTITIONER'S TOOL KIT

Evaluation of Air Quality

James J. Balsamo, Jr., MS, MPH, MHA, RS, CP-FS, CSP, CHMM, DEAAS
Nancy Pees Coleman, MPH, PhD, RPS, RPES, DAAS
Brian Collins, MS, REHS, DLAAS
Gary P. Noonan, CAPT (Retired), MPA, RS/REHS, DEAAS
Robert W. Powitz, MPH, PhD, RS, CP-FS, DABFET, DLAAS
Vincent J. Radke, MPH, RS, CP-FS, CPH, DLAAS
Charles D. Treser, MPH, DEAAS

Editor's Note: The National Environmental Health Association (NEHA) strives to provide relevant and useful information for environmental health practitioners. In a recent membership survey, we heard your request for information in the *Journal* that is more applicable to your daily work. We listened and are pleased to feature this column from a cadre of environmental health luminaries with over 300 years of combined experience in the environmental health field. This group will share their tricks of the trade to help you create a tool kit of resources for your daily work.

The conclusions of this column are those of the authors and do not necessarily represent the official position of NEHA, nor does it imply endorsement of any products, services, or resources mentioned.

An overlooked aspect of our practice is assessing indoor air quality. Most certainly, we use our olfactory senses whenever and wherever we inspect. We smell mice, roaches, sewer and fuel gases, odorants, and putrefaction, to name a few of the noisome things we encounter. But that is where it usually ends with the exception of an occasional complaint investigation. While most complaints are about odors, temperature, drafts, and allergens, we should involve ourselves in identifying problems encountered in indoor air and be in a position to suggest real solutions, whether it be administrative, engineering, or personal behavior. In short, we need to know and actively participate.

For those of us who are institutional practitioners, indoor air quality requires much of our attention. Most buildings that were built in the past 50 years rely exclusively on mechanical ventilation systems. When we assess an indoor air quality issue, we have to be sensitive to demographics of occupants, needs and requirements, distinct building types and function, unique mechanical ventilation systems, and conformance to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards.

Schools, offices, and correctional and other long-term care facilities can encounter problems maintaining consistent comfort levels. We regularly have to deal with seasonal changes: heat to air conditioning and back again. We are also called on to respond to complaints about malodors of all kinds—allergens (both real and imagined), dust contamination, chronic moisture, and mold. Newly occupied and modified buildings pose an additional problem with air flow and off-gassing of finishes and furnishings, particularly with newly installed carpeting. In addition to the usual complaint investigations, our institutional responsibilities includes validating air flow and pressure differentials in isolation rooms, biological containment facilities, and laboratories. We also get involved in determining zone designations in food manufacturing operations where air flow and directionality are crucial in preventing cross contamination.

While many air quality issues are obvious, they require field instrumentation to accurately identify a problem, provide sound technical assistance to maintenance, and hopefully get to a satisfactory resolution to any issue encountered.

Tools in our tool kit provide measurable screening insights into the U.S. Environmental Protection Agency's three strategies to improve indoor air quality: 1) source control, 2) improved ventilation, and 3) selection and maintenance of air cleaners and filtration. Our primary focus during inspection is on source control, followed closely by unique characteristics of the ventilation systems and their performance. To this end, we rely heavily on field instrumentation.

Screening tools allow us to identify the source of complaints and validate containment. These instruments fall into two categories: the first is air quality detection and the second is measuring air flow, directionality, and air pressure gradients. Advances in the development of air quality field instruments have resulted in a wide selection of affordable, highly sophisticated equipment that is simple to operate and maintain, along with being rugged, portable, and highly versatile in our line of work. We do not endorse any specific product realizing there are several excellent choices in each instrument category. We outline specific features, however, that we found best meet our immediate needs. While we are also called on to assess airborne microbes, we will leave that topic for a future column.

Basic Air Quality Detection

The air quality detector we use for screening is a multifunctional (9-in-1) intelligent household-scale instrument available for approximately $60 (Photo 1). They are appropriate for use in the home, office, outdoors, and vehicles.

New air quality detectors use multiangle ventilation holes to accelerate air convection between the air and sensing units. They are designed to measure temperature, humidity, formaldehyde (HCHO), total volatile organic compounds (TVOCs), carbon mon-

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Photo 1. Example of a 9-in-1 air quality detector.

Photo 2: Example of a smoke pencil.

oxide (CO), and carbon dioxide (CO_2). These parameters are self-explanatory and provide basic information for determining comfort levels and clues to environmentally mediated health concerns.

The monitor also measures particulate matter of two size groups: $PM_{2.5}$ (fine particulate matter with a diameter <2.5 µm) and PM_{10} (particulate matter with a diameter <10 µm, which includes dust, soot, and other small particles such as mold spores and pollen). This measurement gives us a clue about the possible origin of the particulate of concern, as well as the design, operation, and maintenance of the ventilation system to contain these pollutants.

Lastly, there are instruments that provide a useful Air Quality Index (AQI). AQI is an excellent tool for communicating about ambient air quality and health. The AQI has six color-coded categories, each representing a range of health concern values, which makes a complex topic easier to understand and explain.

When answering a complaint or question about ventilation, we routinely take all-parameter measurements of the outside air and the indoor air from a location that is not heavily trafficked. This process lets us develop a background pattern to interpret parameters sampled in the target area. Since these field instruments are basic screening tools, comparing monitoring points and subsequent deviations in our sampling provides scientifically sound and appropriate quality control. Detailing the sampling plan and test procedure also meets general requirements for field sampling accountability.

Measuring Ventilation Characteristics

Assessing the operation of a ventilation system includes measuring, or at least defining, air flow, directionality, air pressure gradients, and leak detection. These parameters define living and working spaces, isolation rooms, biological cabinetry, and containment, as well as foundational principles of contamination control. For instance, they provide essential information when designing sanitation practices in food production areas to prevent cross-contamination and are particularly useful in developing CIP (clean-in-place) operational procedures.

The best part of these tests is that they are visual, helping you see the invisible. We can observe airflow, directionality, and air pressure gradients using a few devices. These measurements give us the ability to make operational modifications and to demonstrate substantive changes in air patterns in real time.

An excellent tool for detecting air currents and leaks on a grand scale is the newest iteration of the smoke pencil (Photo 2). This device uses a nontoxic smoke fluid—fog juice—which is the same glycerin-based material used to create smoke at concert venues. There are several similar units available for under $70. They all feature white and colored laser lighting for enhanced dark-space detection. The unit we use is battery-operated and comes in a field kit. It is especially useful in characterizing airflow patterns in larger spaces such as classrooms, laboratories, gymnasiums, kitchens, and dining areas. It is also ideally used to verify isolation rooms and in-use operational characteristics of biological safety cabinets. Further, it is useful for verifying airflow to all areas of a room and for detecting when the air supply is short-circuited by conflicting directional airflow, just to mention a few crucial applications.

Another type of ventilation tracing tool is the smoke pen. The smoke pen is primarily useful in finding drafts and leaks, as well as

Photo 3: Example of a powder-cloud airflow detection system.

Photo 4. Examples of air velocity instrumentation (clockwise, starting from the far left): impeller anemometer, thermal-anemometer, and multi-tool anemometer.

checking the effectiveness of kitchen hoods and exhaust fans, furnace exhausts, and water heater backdrafts. The smoke pen is about the size of an actual pen and fits easily into a shirt pocket. It uses a wick that is lighted to produce safe, nontoxic, thick, dense, low-odor smoke, unlike older, highly caustic-type draft detection systems. The wick lasts about 30 minutes and can be relighted, as necessary.

Both the smoke pencil and the smoke pen are safe to use in occupied areas. They are easy to maintain and operate, and require no calibration or validation. The smoke pen retails for under $50, with 6 wick refills at $40.

We would be remiss if we did not mention the powder-cloud airflow detection system (Photo 3). Also under $50, it uses dense puffs of safe, nontoxic, noncorrosive Borozin powder (zinc stearate). Because Borozin powder is so fine, it floats in the air like smoke but is more persistent visually. This tool is particularly useful for viewing air movement in low airflow conditions.

Air Velocity Measurement

To measure wind speed and volume, we found that we can get a lot done with a simple-to-operate handheld digital CFM anemometer (impeller) airflow tester (Photo 4). It provides us with both air temperature and wind speed readings. The unit is under $50 and battery-operated. We primarily use this field instrument to calculate air turnover rates to ensure health, comfort, and compliance with ASHRAE standards. By measuring the air velocity at the room's air intake and exhaust and measuring both duct openings (using a decimal factor to account for slots and louvers, usually 0.8) it is easy to calculate cubic feet per minute (CFM) entering and exhausting from a room.

With the volume measurement of the room (length × width × height), it is easy to determine the air turnover rate. The formula for calculating air changes per hour (ACH) is: ACH = (CFM × 60)/room volume. This calculation is particularly useful for classrooms, patient and general occupancy areas, laboratories, vivaria, and dog impoundments.

Although anemometers have a ±5% accuracy, they are quite adequate for our purposes. As a side note, we periodically validate the operational accuracy of our units by comparing them to a calibrated thermal anemometer or another similar unit, but this step is not necessary. In all these years, we have never had a problem with failure.

Bottom Line

Simple examination of air quality is part of our responsibility. Air quality is as important as assuring clean water, safe food, and nonpolluting sewage. The air we breathe should also contribute to good health and well-being. The total investment in field instrumentation to meet this challenge is under $200, but the rewards are immeasurable. Starting with the basics, you can always expand and refine your detection systems as needed. We will not be without ours in doing routine work.

Photo Credit: All photos are courtesy of Dr. Robert Powitz.

Contact: powitz@sanitarian.com

Did You Know?

The U.S. Environmental Protection Agency has designated January as National Radon Action Month. Radon is the leading cause of lung cancer deaths among nonsmokers in the U.S. Learn more about the effort to take action against radon at www.epa.gov/radon/national-radon-action-month-information.