RESOLUTION OF THE SICK BUILDING SYNDROME: PART II, MAINTENANCE

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ABSTRACT

Many cases of suspected sick building syndrome (SBS) have been investigated and, in virtually all cases, a physical basis has been hypothesized for resolution of SBS symptoms. However, psychosocial factors also existed in many of these cases. The physical causes seem to occur in four primary categories: lack of proper maintenance, changes in loads from original design, changes in control strategies to meet new objectives (e.g., energy conservation), and inadequate design.

In this paper, we concentrate on findings regarding four categories of maintenance deficiencies: (1) building structure; (2) heating, ventilating, and air conditioning (HVAC); (3) general housekeeping; and (4) a comprehensive maintenance program. Six buildings, which exhibited deficiencies in one or more of these categories, serve as cases for this discussion. Recommended solutions are presented.

Based on our observations of these and other cases, we conclude that with proper attention to maintenance aspects and a comprehensive understanding of HVAC system performance, resolution of SBS is achievable in most buildings.

INTRODUCTION

Energy conservation measures that have been initiated since the 1973 oil embargo have, in many instances, greatly reduced the ventilation of buildings. During this same period, there has been a proliferation of the use of synthetic materials and office automation equipment (e.g., copiers and printers). The increased use of manufactured wood products, carpeting, adhesives that contain volatile organic compounds (VOC), and the increased use of photocopy machines that often emit VOC, ozone, and particulates have all added to the need for increased ventilation. As a result of these emissions and low ventilation rates, some building occupants began to notice irritation soon after entering a particular building and almost immediate relief upon leaving the building.

Occurrences such as these led to the coining of the phrase "sick building syndrome" (Stolwijk 1984) to describe the effects of indoor air contaminants on the building occupants. International indoor air quality experts have essentially agreed that a building manifests SBS when: 1) complaints of certain symptoms associated with acute discomfort (e.g., headaches, fatigue, eye irritation, sore throat, nausea) persist at frequencies significantly greater than 20%; 2) the cause or causes of the complaints are not recognizable; and 3) a substantial percentage of the complainants report almost immediate relief upon exiting the building. Strong evidence of building-related problems is immediate relief from the symptoms upon leaving the building.

INVESTIGATIVE PROCEDURES

The protocol used for evaluating indoor air quality in non-industrial buildings is based on the principles of building diagnostics (Building Research Board 1985). The diagnostic procedure is based on a three-phase approach (Woods et al. 1987): consultation, qualitative diagnostics, and quantitative diagnostics. All of the cases reported in this paper, except one, were diagnosed under Phase 1 of our three-phase approach. Phase 1 does not involve any physical data recording (i.e., it consists mainly of information-gathering meetings, discussions with occupants, and a walkthrough) and hence a limited amount of information is available. Although some occupants in the cases presented here manifested SBS symptoms, the objectives of the investigations were not to explicitly demonstrate the existence of the syndrome. Rather, the objectives were to identify recommendations that would mitigate the symptoms and complaints.

Many cases of suspected SBS have been investigated, and physical causes for occupant complaints have been documented. Psychosocial factors also existed in many of the cases investigated. Often the psychosocial factors involved employee distrust of management that resulted from a perceived no-action response by the management to employee complaints. Job satisfaction was also suspected as part of the psychosocial issues in some of the cases. This paper addresses only the suspected physical causes and not the aggrandizing psychosocial factors.

We have found that the physical causes for SBS fall into four major areas:

1. Lack of system maintenance,
2. Changes in control strategies to meet new objectives during the lifetime of the building (e.g., energy management, cost containment),
3. Changes to thermal and contaminant loads imposed during the lifetime of the building, and
4. Inadequate design of the original system or building.

In a previous paper presented at IAQ '87 (Woods et al. 1987), we concentrated on findings regarding design deficiencies. In this paper, we will focus on inadequate maintenance. Many other investigators (Binnie 1988; Chow and Wang 1987; Collett et al. 1988; Ferahian and Mice 1988; Gibbs 1987; Morey 1988; Robertson 1988) have reported on maintenance deficiencies found in buildings with SBS or building-related illness-type symptoms. We have found four categories of maintenance deficiencies:

1. Building structure,
2. HVAC,
3. General housekeeping, and
4. Comprehensive maintenance program.

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Examples of these maintenance deficiencies and their proposed solutions are presented here.

FIELD EXAMPLES

The maintenance deficiencies in six different buildings are described to illustrate the various classes of problems. Often, the same building exhibited deficiencies in one or more of the four categories. SBS complaints have been exhibited in each of the example buildings.

Building 1

Building 1 was a 25-year-old, five-story municipal building of approximately 300,000 ft². The building was air-conditioned by four separate HVAC systems. The HVAC systems were located in a penthouse on the roof of the building, and each system served a quadrant (all floors) of the building. The systems were constant-air-volume (CAV), dual-duct systems. On each of the systems, there were "throwaway" fiberglass pre-filters on the outdoor air intakes, inoperative (no longer used) electronic air cleaners (EAC) in the mixed air, and "throwaway" pleated paper filters in the mixed air. Individual mixing boxes were used to condition the perimeter offices and the building core was served by four mixing boxes per floor.

Occupants of diagnosed areas cited temperature conditions as a problem and some occupants complained that the space was "stuffy." Occupants of the basement and first floor reported—in addition to temperature complaints—headaches, fatigue, and drowsiness. These symptoms reportedly went away upon leaving the building. Based on our Phase 1 investigation, Building 1 suffered from maintenance deficiencies in the following categories: HVAC, general housekeeping, and comprehensive maintenance program.

There were missing pre-filters in each of the four HVAC systems. The old EACs had not been operated in years and the collector plates were caked with layers of dirt. The interior walls of the mixed air plenum, both upstream and downstream of the EAC, were also covered with dirt. There were two floor drains in the mixed air plenum for the EAC automatic wash cycle. The traps of both drains were dry, thereby allowing sewer gases to enter the mixed air plenum. The ductwork was rusted through under the cooling coils on two of the units. The condensate water would run out of the duct in three or four different places and into a maze of troughs that would catch the water and channel it off to a nearby floor drain. The perimeter mixing box units were very dirty and some of the units did not function properly. Another sign of poor maintenance of the mixing box units was old, moldy food lying in them.

Housekeeping was inadequate in many areas of the building. What appeared to be years of accumulation of dust and dirt was on some of the windowsills. Due to a shortage of storage space, employees were placing articles on top of the perimeter units, thereby blocking a portion of or most of the units' discharge. Overcrowding in some offices resulted in file cabinets being placed in front of low sidewall return air grilles, thereby severely restricting the return airflow.

There was a complete absence of a comprehensive maintenance policy. Filters were changed on a regular basis but that was all. Other maintenance was done only on an as-needed basis. The "chief engineer" and his "righthand man" were relatively new to the job, did not understand the HVAC system, and had not had any type of training on the systems. The lack of training was probably partly responsible for the absence of a comprehensive maintenance program.

As a result of the Phase 1 investigation, the following recommendations were made to mitigate the problems:

- Clean the plenums of the air-handling units, replace missing pre-filters, and keep the traps for the floor drains full of water or seal them off. It was further recommended that an engineering study be conducted to determine if the HVAC systems should be renovated or replaced. At a minimum, the rusted-through ductwork should be replaced and the cooling coil drain pans repaired. The perimeter mixing box units should be checked and repaired if necessary to ensure that all are in proper working order.
- The housekeeping procedures should be reviewed and changed where necessary. Where necessary, offices should be rearranged so file cabinets will no longer block return air grilles. The employees should be informed that material should not be placed on top of the supply outlets of the perimeter mixing box units.
- A comprehensive maintenance program for the building should be developed. Part of the program should include training for the building engineer and engineering staff.

Building 2

Building 2 was a 22-story, multi-tenant office tower. The building was 32 years old and had approximately 20,000 ft² per floor. There were separate HVAC systems on each floor (for air-conditioning the core on that particular floor) and four HVAC systems (two in the basement and two on the roof) that supplied perimeter induction units on all floors of the building. All of the HVAC systems were CAV units. Prefilters in the outdoor air were of the fiberglass throwaway type and the filters in the mixed air were pleated paper. The HVAC equipment was the original equipment but it had been meticulously maintained.

Occupants reported regularly experiencing symptoms of headache, nasal and sinus congestion, coughing, eye irritation, and difficulty wearing contact lenses. The complainants indicated that their symptoms diminished shortly after leaving work.

Based on our Phase 1 investigation, Building 2 had maintenance problems in the following categories: building structure and HVAC.

The structural design problem involved two of the outdoor air intakes. The building was located on a corner with busy streets in front of and on one side of the structure. There were alleys on the other two sides of the building. The outdoor air intakes for the two HVAC systems in the basement were located at street (alley) level on the back side of the building. The problem was caused by transients who slept in the alley and used the outdoor air intakes as urinals. The garbage dumpsters for the building were also kept at one end of the alley, and garbage odors were entering the outdoor air intake closest to the dumpsters.

The other problem resulted from a maintenance deficiency of the HVAC system, even though a comprehensive maintenance program existed. The central mechanical equipment was meticulously maintained but the perimeter induction units were only serviced on an as-needed basis and cleaned only infrequently. The reason for this was that office remodeling had made the units very difficult to access and hence they were neglected.

As a result of the Phase 1 investigation, the recommended solutions to mitigate these problems were:

- Erect gates at both ends of the alley to keep out transients and raise the outdoor air intake by the dumpsters to minimize the entrainment of garbage odors.

- All of the perimeter induction units should be cleaned and put back on a regular maintenance schedule.

Building 3

Building 3 was a two-story office building, seven years old, with 176,000 ft^2 of total floor area. The building was conditioned by four HVAC systems: one multi-zone unit, two CAV units, and one VAV unit. "Throwaway" fiberglass filters were used on the multi-zone system and pre-filters in conjunction with bag filters were used on the other three systems.

Both SBS symptoms and a suspected building-related illness (BRI) case were present. The reported symptoms typical of SBS included eye irritation, headache, rhinitis, and lethargy. All of the occupants who reported such symptoms also reported that their symptoms diminished upon leaving the building. The suspected BRI case involved one individual who was having respiratory allergic reactions.

Based on our Phase 1 investigation, Building 3 suffered from deficiencies in HVAC maintenance.

Maintenance of the HVAC systems was performed by an outside contractor and there was a comprehensive maintenance program in place. Filter and mechanical equipment maintenance were performed on a regularly scheduled basis. The problem was the sound liner in the discharge air plenum of the VAV system, which was heavily contaminated with *Penicillium*. A limited number of bulk samples were taken during this Phase 1 investigation for the purpose of identifying the fungal growth on the sound liner. It is suspected that the fungal growth was overlooked during routine inspections because the maintenance personnel were not trained to look for evidence of fungal growth nor were they familiar with the potential risk.

The recommended solution, resulting from our Phase 1 investigation, was to remove the sound liner from the plenum and disinfect the plenum with a dilute bleach solution. The plenum in this instance was large and hence it was more economical to remove the liner than to replace the plenum. Whether it is more economical to remove the liner or replace the ductwork generally will depend on its size and location. It is recognized that removing the sound liner will increase the noise transmission and installation of alternative noise-reducing methods (e.g., in-duct attenuators) may be required.

Building 4

Building 4 was a two-story office building with 100,000 ft^2 on the first floor and 25,000 ft^2 on the second floor. The building was originally constructed in 1960 as a warehouse with office space in the two-story portion of the building. It was completely converted to office space approximately six years ago. The two-story portion of the building was conditioned by two multi-zone HVAC systems. The mechanical equipment rooms housing each of the systems also acted as the mixed air plenum for the respective unit. "Throwaway" fiberglass filters were used on each of the two systems. The remaining single-story structure was air-conditioned by four VAV HVAC systems. All of the VAV systems had "throwaway" fiberglass filters.

Occupants reported symptoms of headaches, lethargy, and difficulty in concentrating. These symptoms reportedly diminished upon leaving the building. Temperature complaints and complaints of "stuffy" or "stale" air were also very common.

The problems in Building 4, based on our Phase 1 investigation, were in the following categories: building structure or envelope, HVAC, and no comprehensive maintenance program.

The building envelope problem was water leakage at the tops of the windows on one side of the building. The problem only occurred when it rained and the wind was from a direction that would drive the rain into the windows. The resulting leaks would wet the ceiling tiles along the windows. There was no evidence of microbial growth on the ceiling tiles but the potential for microbial-related problems definitely existed.

The HVAC problem was with the multi-zone units. The mechanical equipment rooms, which also functioned as mixed air plenums, were not clean and were used for storage of old pipe, old filter boxes, janitorial supplies, and miscellaneous items. Using the mixed air plenum for storage makes it harder to keep the plenum clean, it can add contaminants (e.g., dirt and VOC) to the supply airstream, and the cardboard boxes are nutrients for microorganisms that could, in turn, contaminate the supply air. An additional problem with the multi-zone systems was that a panel was missing on the left- and right-hand sides of the filter rack and this allowed some of the air to directly bypass the filters.

The chief engineer for the building and its HVAC systems had only obtained responsibility for the building days before our site visit. What the chief engineer inherited from the previous responsible party was no maintenance program of any kind, no maintenance records, and an incomplete set of engineering drawings. Maintenance people who had been associated with the building for a number of years indicated that the only regular maintenance was filter changing. Everything else was done on an as-needed repair basis.

As a result of our Phase 1 investigation, the following recommendations were made to mitigate the SBS problems experienced in Building 4:

- The windows leaking from wind-driven rain should be recaulked. All ceiling tiles that have been water damaged should be replaced.
- The missing filter rack panels on the two multi-zone units should be replaced. The mechanical equipment rooms housing the multi-zone units should be cleaned and all stored material removed.
- A comprehensive maintenance program for the building should be developed. A complete set of engineering drawings should be made available. A training program for the building engineer and his staff should be implemented, even if the maintenance program recommends using an outside contractor.

Building 5

Building 5 was a 12-story hospital with approximately 15,000 ft^2 per floor. The building was approximately 25 years old. The HVAC systems were located in the basement and in a penthouse on the twelfth-floor roof. All of the HVAC systems were CAV and some used recirculated air and others used 100% outdoor air. "Throwaway" fiberglass filters were used on some systems and pre-filters in conjunction with bag filters were used on other systems. The operating room HVAC systems were new, had HEPA filters, and were not included in the investigation. All three phases of our investigative approach were used in diagnosing this building.

Symptoms reported by occupants varied somewhat from one area to another, but symptoms common to all were headache, eye irritation, dry mucous membranes, drowsiness, and dry skin. Some occupants also reported unexplained memory loss. These symptoms reportedly diminished shortly after leaving the building. Based on Phase 1, 2, and 3 investigations, the building suffered in all four problem areas: structure, HVAC, housekeeping, and comprehensive maintenance program.

There were two envelope- or structure-related problems. One was water leakage around the windows due to wind-driven rain and the other was building-related wind recirculation patterns which, at times, resulted in the kitchen exhaust contaminating the outdoor air intake. The caulking and grout around the windows was falling out and wherever it was missing, wind-driven rain would result in a water leak. The other structure-related problem involved the tower structure of the hospital and the location of the kitchen exhaust and outdoor air intake on the fifth-floor roof. Wind recirculation patterns sometimes would carry the kitchen exhaust up off the roof and then back down and directly into the outdoor air intake.

Most of the HVAC systems were original equipment and hence were approaching or at the end of their expected service life. Plenums and ductwork around cooling coils were rusted out due to condensate leaks or drain pan overflows. Some of the control functions had been disconnected or modified without regard, apparently, for the overall effect on system performance. The plenums in all of the systems were dirty and filter maintenance appeared to be erratic. The fan coil units around the perimeter appeared as though they were rarely, if ever, cleaned.

Housekeeping in areas other than patient care areas was very poor. Housekeeping practices such as using the corridors for storage and the handling of clean and dirty linen were inadequate. A portion of the problem was due to inadequate facilities and insufficient staff.

There was no comprehensive maintenance program in effect at the hospital. There was a filter replacement schedule but it was not followed very rigorously. Some of the systems were completely neglected and only attended to on an emergency basis.

As a result of our Phase 1, 2, and 3 investigations, the following recommendations were made to mitigate the problems:

- Repair and/or replace the caulking and grout around the windows to stop the wind-blown rain leakage problems.
- Initiate an engineering study to determine if the HVAC equipment should be replaced or renovated. Short-term recommendations were to clean the HVAC system plenums, clean the coils and drain pans, follow the filter replacement schedule, and clean the perimeter fan coil units.
- The budget for housekeeping should be increased to allow the hiring of an adequate staff. All housekeeping policies should be reviewed and updated where necessary. The housekeeping policies should be enforced to ensure that the work gets done.
- A comprehensive maintenance program should be developed and the budget increased to allow the implementation of the program. Included in the program should be HVAC training for the building engineer and his staff.

Building 6

Building 6 was constructed in 1971 and was six stories, two of which were below grade. The total area of the facility was approximately 92,000 ft^2. Basement level 1 housed a parking garage and two mechanical equipment rooms, which housed the HVAC equipment for the garage and basement level 2. A penthouse housed two additional mechanical equipment rooms that housed the HVAC equipment that air-conditioned floors 1 through 4. All of the HVAC systems were CAV.

Occupants reported experiencing symptoms of nausea, dizziness, eye and throat irritation, numbness in fingertips, and loss of depth perception. The occupants reported that their symptoms seemed to subside shortly after leaving the building.

Based on our Phase 1 investigation, the building suffered from maintenance problems in the following categories: building envelope, HVAC, and comprehensive maintenance program.

The envelope-related problem was the roof. A new insulated roof had been completed approximately one year prior to our site visit. The new roof was fabricated by spraying urethane foam over the old roof and then covering that with an elastomer spray coating. When the elastomer spray coating was applied, some of the roof drains were inadvertently plugged with the elastomer coating. As a result, there was inadequate drainage and a roof leak developed. The roof leak had caused some ceiling tiles to get wet, although at the time of our site visit there was no evidence of microbial contamination.

The maintenance deficiencies with the HVAC equipment were infrequent filter changing, dirty coils, and dirty drain pans. At the time of the site visit, the filters, coils, and drain pans in all of the air handlers were found to be dirty. Discussions with the building maintenance person indicated that the filters were changed on an "occasional" basis.

It was discovered that there was no comprehensive maintenance program in effect and efforts were just beginning to implement one. A few days before our site visit, the building manager had contracted with a maintenance firm to perform monthly HVAC equipment inspections and "as-needed" service.

The following recommendations, as a result of our Phase 1 investigation, were made to help mitigate the SBS problems in the building:

- Unplug the roof drains and ensure that there is adequate drainage of the roof. Repair the roof leaks and replace the damaged ceiling tiles.
- Replace air filters in all of the air handlers and clean the coils and drain pans.
- Develop a comprehensive maintenance program that includes all of the mechanical equipment, controls, and building structure. Such a program will help ensure that occupant health, well-being, and comfort are not being compromised while the systems are being operated cost effectively.

DISCUSSION

Through October 1988, we have investigated more than 50 cases, and it is estimated that approximately 75% of all cases have had maintenance deficiencies sited as one of the causes of their SBS complaints. A ranking—with most frequent being first—of the four maintenance deficiencies discussed in this paper would be: HVAC, comprehensive maintenance program, housekeeping, and building structure. Part of the maintenance problem, in many instances, is due to budgetary constraints and inadequately trained personnel. Building owners and/or managers may cut maintenance budgets without noticing any adverse effects for a period of time, maybe years. When problems do occur, such as SBS complaints, the managers may think that the people are complaining just for the sake of complaining. When the complaints continue, the building manager or responsible party will often hire a consulting firm to come in and "check" the air. We suspect that inadequate maintenance is rarely thought to be part of the problem. Inadequately trained building engineering or maintenance personnel may also be indicative of the slashed budget problem. Often, building engineers and their associates are not adequately trained to operate and maintain an HVAC system.

CONCLUSION

Based on our observations, it is our opinion that when care is taken to ensure that the HVAC equipment is properly maintained, operated, and that an appropriate amount of outdoor air enters the building and is properly distributed, complaints can be minimized and resolution of the SBS is achievable in most buildings. Follow-up diagnostics are not typically requested by clients and hence final results are generally never known (i.e., what happened after recommendations were implemented). Speculation on the nature of the possible agent causing the complaints in each of the case buildings was not done because one of the characteristics of SBS is that the cause(s) of the complaints are not identifiable.

The existence of a comprehensive maintenance program is of the highest importance because such a program should include specifications for maintenance of the building structure and envelope (i.e., exterior walls, roof, etc.), maintenance of the HVAC equipment, and general housekeeping procedures. Key maintenance items to be included are:

—repair of all building envelope leaks,
—regularly scheduled filter changing in all HVAC equipment,
—regularly scheduled inspection, and replacement if necessary, of the air duct liner,
—regularly scheduled coil and drain pan cleaning,
—regularly scheduled maintenance of the mechanical equipment,
—regularly scheduled maintenance and calibration of the controls, and
—specification of the cleaning agents to be used in the occupied space as well as the cleaning schedule.

Furthermore, proper maintenance procedures will probably enhance the energy efficiency of the HVAC equipment while providing acceptable environmental conditions in the occupied spaces.

REFERENCES

Binnie, P.W.H. 1988. "Indoor air quality system maintenance and contamination control." *Proceedings of the CIB Conference, Healthy Buildings '88*, Berglund, B. et al. (Eds.), Swedish Council for Building Research, Vol. 3, pp. 447–456.

Building Research Board, National Research Board, National Research Council, National Academy Press. 1985. *Building diagnostics: a conceptual framework*. Washington, DC.

Chow, D.B., and Wang, D.U. 1987. "Some commonly found problems in HVAC systems of public offices." *Practical Control of Indoor Air Problems, Proceedings of the ASHRAE IAQ '87*, pp. 299–306. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Collett, C.W.; Sterling, E.M.; and Arundel, A.V. 1988. "Changing sick buildings into healthy buildings." *Proceedings of the CIB Conference, Healthy Buildings '88, Berglund, B. et al. (Eds.), Systems, Materials, and Policies for Healthier Indoor Air*, Vol. 3, Swedish Council for Building Research, pp. 55–60.

Ferahian, R.H., and Mice, M. 1988. "Building codes for ensuring good indoor air quality." *Proceedings of the CIB Conference, Healthy Buildings '88*, Berglund, B. et al. (Eds.), *Systems, Materials, and Policies for Healthier Indoor Air*, Swedish Council for Building Research, Vol. 3, pp. 671–678.

Gibbs, L.M. 1987. "Indoor air problems at an academic research institution." *Proceedings of the ASHRAE IAQ '87, Practical Control of Indoor Air Problems*, pp. 173–177. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Morey, P.R. 1988. "Microorganisms in buildings and HVAC systems: a summary of 21 environmental studies." *Proceedings of the ASHRAE IAQ '88, Engineering Solutions to Indoor Air Problems*, pp. 10–21. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Robertson, G. 1988. "Source, nature, and symptomology of indoor air pollutants." *Proceedings of the CIB Healthy Buildings '88*, Berglund, B. et al. (Eds.), *Systems, Materials, and Policies for Healthier Indoor Air*, Vol. 3, Swedish Council for Building Research, pp. 507–516.

Stolwijk, J.A.J. 1984. "The 'sick building' syndrome." *Indoor Air: Recent Advances in the Health Sciences and Technology*, Swedish Council for Building Research, Stockholm, pp. 23–29.

Woods, J.E.; Janssen, J.E.; Morey, P.E.; and Rask, D.R. 1987. "Resolution of the 'sick' building syndrome." *Proceedings of the ASHRAE IAQ '87, Practical Control of Indoor Air Problems*, pp. 338–347. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Woods, J.E.; Morey, P.R.; and Rask, D.R. 1989. "Indoor air quality diagnostics: qualitative and quantitative procedures to improve environmental conditions." *Design and Protocol for Monitoring Indoor Air Quality*, ASTM STP-1002, pp. 80–98. Philadelphia: American Society for Testing and Materials.

DISCUSSION

Richard J. Shaughnessy, Center for Environmental Research and Technology, University of Tulsa, Tulsa, OK: For your diagnostics procedure, if required, what specific contaminants do you look for? I understand that Honeywell has specific criteria pollutants that will be examined and was interested in how these were chosen above others.

C.A. Lane, Honeywell Indoor Air Quality Diagnostics, Golden Valley, MN: Honeywell IAQD performs a three-phase diagnostics procedure to identify and solve indoor air quality problems in buildings. In the first phase (i.e., the consultation phase), the building is characterized as a "system" of components, which include the building structure, envelope, interior spaces, and the services (e.g., the HVAC systems). The purpose of this phase is to identify the relationship between the symptoms expressed by the occupants, the possible sources of contaminants, and the physical characteristics of the building systems. No objective data are obtained in this phase.

If additional diagnostics are required, the second phase (i.e., the qualitative diagnostics phase) is performed. Typically, this phase consists of an engineering analysis of the building systems, which includes a thermal and air contaminant loads analysis and an analysis of the HVAC control systems. Normally no data are obtained in this phase, except for occasional measurements (e.g., airflows, etc.) to characterize the performance of the HVAC systems servicing the complaint areas.

If additional diagnostics are required, the third phase (i.e., the quantitative diagnostics phase) is performed. In this phase, the areas of maximized exposure to contaminants, and the areas of the most susceptible occupants are identified. Objective data are obtained in these areas as well as performance data for the HVAC systems that service the areas. The specific data obtained will depend on the nature of the problem; however, sampling for carbon dioxide, total particulates, total hydrocarbons (i.e., FID detector), VOCs (i.e., Tenax sampling), illuminance, luminance, acoustics, dew point, dry-bulb temperature, mean radiant temperature, and air velocity is typically performed. Microbial sampling also will be performed if conditions indicate.

Honeywell IAQD uses performance criteria specified in ASHRAE Standards 55-1981 (i.e., thermal) and 62-1981R (i.e., indoor air quality), and IES standards. IAQD has elected to establish performance criteria for gaseous contaminants that are based on the lower concentration of either one-tenth the TLV or twice the odor threshold value.