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## Case Studies

# Evaluation of Verbal Communication Problems and Indoor Environmental Quality at a Government Service Office

*Dawn Tharr, Column Editor*

Reported by Randy L. Tubbs and Teresa A. Seitz

### Introduction

The National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized representative of employees at an office of the U.S. Department of Justice, Immigration and Naturalization Service (INS). The INS information officers were concerned about verbal communication problems when they interacted with the public in their office. The office configuration made the information officers raise their voices in order to be both heard and understood by the public customers that they served. One INS employee had been seen by a physician and was told that the office conditions led to their voice loss. The employees felt the plexiglass barrier between the information officers and the public, and the ventilation system that conditioned the air in the office, were the contributing factors of the communication difficulties. The employees also expressed concern about a perceived increase in illnesses thought to be related to poor ventilation.

### Background

The INS office was located on the first floor of a multistory office building. A large portion of the leased space had individual offices or larger multiperson offices. The location also had a holding cell for people detained by the INS. The area of the employees' concern was a public waiting room and reception area where INS information officers met with the public to answer questions about immigration to the United States and to distribute forms needed in the immigration process. Most people that visit the INS do not use English as their first language, and many of them were unable to speak any English at all.

In 1996, one of the INS information officers experienced voice problems at work. The employee was seen over many months by an audiologist who believed that ventilation problems, high ambient noise levels, and no voice amplification system were contributing to the patient's vocal symptoms. The audiologist recommended that the employee be given an amplification system to reduce strain on the voice. However, the modifications that were made to the work area did not include such a system. The information officer never completely recovered and eventually retired.

### Methods

*Noise*

Real-time area noise sampling was conducted with a Larson-Davis Laboratory Model 2800 Real-Time Analyzer (Provo, UT) and a Larson-Davis Laboratory Model 2559 (Provo, UT) half-inch random incidence response microphone. The analyzer allowed for the analysis of noise into its spectral components in a real-time mode. The half-inch diameter microphone had a frequency response range (±2 decibels [dB]) from 4 Hertz (Hz) to 21 kilohertz (kHz) that allowed for the analysis of sounds in the region of concern. One-third octave bands and full octave bands consisting of center frequencies from 20 Hz to 20 kHz were integrated and stored in the analyzer. The analyzer was mounted on a tripod and was placed at various locations where the INS information officers and the public conducted business. The microphone was placed at approximately the level of peoples' ears.

*Indoor Environmental Quality*

A discussion was held with the representative responsible for the building lease to determine if there had been a history of indoor environmental quality (IEQ) complaints and to obtain background information on the ventilation systems serving the INS space. To evaluate current environmental conditions, air temperature, relative humidity (RH), and carbon dioxide ($CO_2$), measurements were made with TSI Q-Trak Model 8550 IAQ Monitors (St. Paul, MN). Two stationary monitors placed in the information officer reception area and the customer side reception area recorded temperature, RH, and $CO_2$ concentration every five minutes from about 7:45 a.m. until 1:45 p.m. One additional monitor was used to take periodic (spot) measurements throughout the day in the records room, investigations work area, public waiting room, computer room, and a private office.

A TSI Model 8370 AccuBalance Flow Measuring Hood (St. Paul, MN) was used to measure supply and return airflow rates in the waiting room, reception areas, and a private office. Smoke tubes were used to visually assess airflow patterns in the waiting room and reception areas. Access to the air handling units for visual inspection was not possible during the NIOSH site visit.

## Evaluation Criteria

*Noise*

The A-weighted decibel is the preferred unit for measuring sound levels to assess worker noise exposures. The decibel scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels that are audible to the human ear. Because the decibel scale is logarithmic, increases of 3 dB(A), 10 dB(A), and 20 dB(A) represent a doubling, 10-fold increase, and 100-fold increase of sound energy, respectively. It should be noted that noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean.

The occupational noise regulation promulgated by OSHA,[1] as well as the limits published by NIOSH[2] and ACGIH®,[3] are not appropriate for the situation observed at this work location. The above referenced criteria are designed to prevent hearing loss from exposures to intense noise levels. However, noise of intensities lower than that which may cause a loss of hearing can be disruptive in the workplace. Interference with speech and interruption of office activities are possible results of unwanted noise. The noise can interfere with the efficiency and productivity of the office staff and be detrimental to the occupants' comfort, health, and sense of well-being. One set of noise criteria for occupied interior spaces, the balanced noise criteria (NCB) curves, has been devised to limit noise to levels where satisfactory speech intelligibility is achieved.[4–6] The criteria were devised through the use of extensive interviews with personnel in offices, factories, and public places, along with simultaneously measured octave band sound levels. The interviews consistently showed that people rate noise as troublesome when its speech interference level is high enough to make voice communications difficult. The recommended space classifications and suggested noise criteria range for steady background noise heard in various indoor occupied activity areas are shown in Table I.

*Indoor Environmental Quality*

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[7,8] Among these factors are imprecisely defined characteristics of heating, refrigerating, and air-conditioning (HVAC) systems; cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination; and physical factors such as thermal comfort, lighting, and noise.[7–11] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts are beneficial.[12] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[13] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either

indoor or outdoor sources.[14]

There are also reports describing results that show occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than the measurement of any indoor contaminant or condition.[15] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16,17]

Problems that NIOSH investigators have found in the non-industrial indoor environment have included poor air quality due to ventilation system

**TABLE I**
Recommended space usage for balanced noise criteria range in occupied indoor areas

| Type of space and acoustical requirements | NCB curve |
|---|---|
| Concert halls, opera houses, recital halls | 10–15 |
| Large auditoriums, large drama theaters, large churches | Not to exceed 20 |
| Small auditoriums, small theaters, small churches, music rehearsal rooms, large meeting and conference rooms, and executive offices | Not to exceed 30 |
| Bedrooms, hospitals, residences, apartments, hotels | 25–40 |
| Private or semi-private offices, small conference rooms, classrooms, libraries | 30–40 |
| Large offices, reception areas, retail shops and stores, cafeterias, restaurants | 35–45 |
| Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas | 40–50 |
| Light maintenance shops, industrial plant control rooms, office and computer equipment rooms, kitchens, laundries | 45–55 |
| Shops, garages | 50–60[A] |
| Work spaces where speech or telephone communication is not required | 55–70 |

[A]Levels above NCB 60 are not recommended for any office or communication situation.

deficiencies, overcrowding, volatile organic chemicals from office furnishings, office machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants. Comfort problems due to improper temperature and relative humidity (RH) conditions, poor lighting, and unacceptable noise levels, as well as adverse ergonomic conditions and job-related psychosocial stressors were also noted. In most cases, however, no environmental cause of the reported health effects could be determined.

Standards specifically for the nonindustrial indoor environment do not exist. With few exceptions, pollutant concentrations observed in the office work environment fall well below the NIOSH, OSHA, and ACGIH published occupational standards or recommended exposure limits.[3,18,19] The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation and thermal comfort guidelines.[20,21] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related symptoms that might be caused by airborne living organisms or their effluents.[22]

Measurement of indoor environmental contaminants has rarely proved to be helpful, in the general case, in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proved relationship between a contaminant and a building-related illness. However, measuring ventilation and comfort indicators such as carbon dioxide ($CO_2$), temperature, and RH is useful in the early stages of an investigation for providing information relative to the proper functioning and control of HVAC systems.

*Carbon Dioxide*

$CO_2$ is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. ASHRAE's most recently published ventilation standard, ASHRAE 62-1999, *Ventilation for Acceptable Indoor Air Quality*, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces, and 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors.[21] Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

Indoor $CO_2$ concentrations are normally higher than the generally constant ambient $CO_2$ concentration (range 300–350 parts per million [ppm]). $CO_2$ concentration is used as an indicator of the adequacy of outside air supplied to occupied areas. When indoor $CO_2$ concentrations exceed 800 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected.[23] Elevated $CO_2$ concentrations suggest that other indoor contaminants may also be increased. It is important to note that $CO_2$ is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual level.

*Temperature and Relative Humidity*

Temperature and RH measurements are often collected as part of an indoor environmental quality investigation because these parameters affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperature.[24] Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The American National Standards Institute (ANSI)/ASHRAE Standard 55-1992 specifies conditions in which 80 percent or more of occupants would be expected to find the environment thermally acceptable.[20] Assuming slow air movement and 50 percent RH, the operative temperatures recommended by ASHRAE range from 68–74°F in the winter, and from 73–79°F in the summer. (The difference between the two is largely due to seasonal clothing selection.) ASHRAE also recommends that RH be maintained between 30 and 60 percent RH.[20] Excessive humidity can support the growth of microorganisms, some of which may be pathogenic or allergenic.

## Results

The information officers dealt with customers of the INS in three areas: a public waiting area, a separate reception area where the customer spoke to an information officer, and the area where up to three officers worked with the public. Customers entered the building and passed through a security check point, including a metal detector, were seated, and waited until their number was called by an information officer through an intercom system. Once called, they went through a door into the reception area to meet with an information officer. [This was an open area, with three work stations where the customer met with an officer.] There was a plexiglass barrier between the officers and the customers with a four-inch diameter round hole, approximately five feet above the floor, designed for the two individuals to talk with each other. A slot was located above a counter at the bottom of the plexiglass barrier to allow papers and forms to be passed back and forth. There were no barriers between the three customer positions.

On the officers' side of the barrier was a small room that contained three work stations along with shelves for forms, a laser printer, and a cash register. Each of the three stations had a working counter that was 23 inches deep at the slot and 31 inches deep on either side of the slot. A personal computer with video screen and keyboard was located on the counter surface at each station. An additional plexiglass barrier was located on the counter between each of the three officer's stations. Each officer location had a tall chair for use if desired by the employee. The chair at one location had a seat pan 28 inches from the floor with the working counter at a height of 42 inches. Thin, rubberized mats were on the floor

at each station. Prior to the NIOSH site visit, a round, metal, slotted device had been placed in the barrier hole as a way to further reduce the air moving through the hole. It had no sound amplification capabilities and the employees felt that it degraded communications, and was removed by the time of the evaluation.

*Noise*

Area noise measurements were made throughout the day in the area where the information officers worked. The measurements were made while the INS officers were conducting business with the public, so that the noise levels represent the ambient sound levels in an occupied space. Both A-weighted and unweighted sound pressure levels (SPL) were recorded in addition to the spectral measurement. Noise levels in the information officers' room were measured between 64 and 67 dB(A) and between 67 and 70 dB SPL. On the customers' side of the barrier, similar measurements were recorded between 58 and 66 dB(A) and between 65 and 70 dB SPL.

To compare the occupied room noise levels to the NCB criteria, octave-band sound levels were recorded on the customers' side of the reception area (Figure 1). When three customers were at the information positions, the A-weighted level was measured at 65 dB(A) and the unweighted sound at 70 dB SPL. The individual octave bands were fairly consistent having sound levels between 55 and 65 dB. A direct comparison to the NCB-40 criterion, which is recommended for reception areas (Table I) and to the NCB-60 criterion, which is the cutoff level when communication is desired in the occupied area, shows that the higher frequency noise components (2k, 4k, and 8k Hz) of the room are nearing the NCB-60 curve. With the exception of the two lowest frequency bands, the NCB-40 criterion is exceeded by the measured sound levels in the customer reception area.

Another sound measurement that was made during the evaluation was made in attempt to show the effect of the plexiglass barrier on communications between the information officer and the customer. Smaller bands of sound, one-third octaves, were recorded on both sides of the hole in the plexiglass. On the customer side of the barrier, the microphone was placed at the height of the opening, but 6–10 inches to the side to duplicate the situation where the customer does not have their ear directly in the opening. The microphone was approximately 6–10 inches from the mouth of the officer for the measurement made on the officer's side of the barrier. Both measurements integrated the sound for 60 seconds while the officer and customer were conversing. These results are shown in Figure 2: The barrier does reduce the sound produced by the information officer, particularly in the higher frequency bands above 1 kHz. The reduction was found to be as much as 10 dB in the frequencies that are involved in human speech recognition.[25]

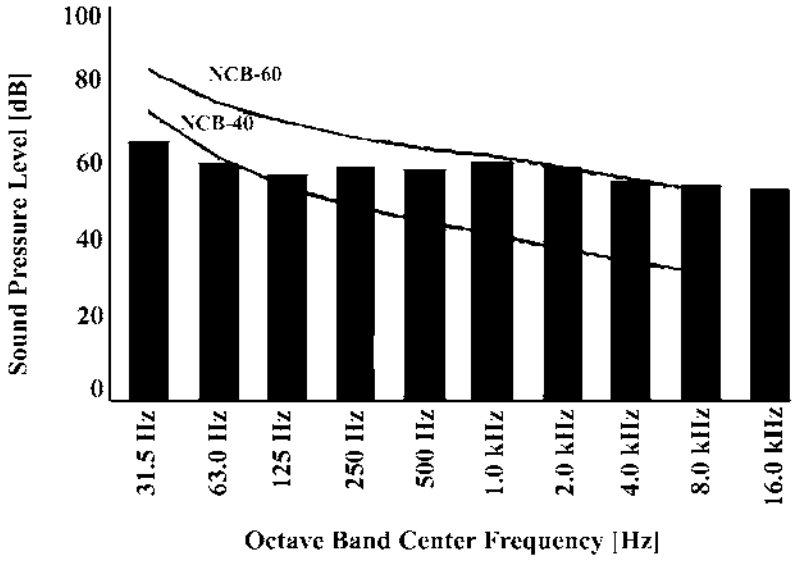


**FIGURE 1**
Octave-band sound levels on the customer side (center of room).

*Indoor Environmental Quality*

The lease representative indicated that he had received complaints in the past regarding thermal comfort and problems with air flow in the reception area. He also indicated that the building owner was the current building manager. At the time of the NIOSH site visit, mechanical diagrams and ventilation system specifications were not available for review.

As shown in Table II and Figures 3 and 4, $CO_2$ concentrations ranged from about 600 ppm to nearly 3200 ppm on the day of measurement. $CO_2$ concentrations exceeding the NIOSH guideline of 800 ppm were recorded throughout the evaluated area. Thermostats controlling air delivery to the INS space were located in the waiting room, investigation areas, records room, and computer room. The thermostats could be set on heating, cooling, or off, as well as on automatic or fan modes. In the automatic mode, air is supplied only when the thermostat calls for heating or cooling; when the thermostat is satisfied or placed in the off position, there is no air delivered to the space. When placed in the fan mode, there is a continuous supply of air. The air is conditioned (heated or cooled) as needed depending on the thermostat set points. The thermostats were found to be set on off and auto, with the exception of the computer room thermostat which was set on auto and cooling.

At 9:10 a.m., there were 43 people present in the waiting room, and the $CO_2$ concentration approached 3200 ppm. At that time, the thermostat in the waiting

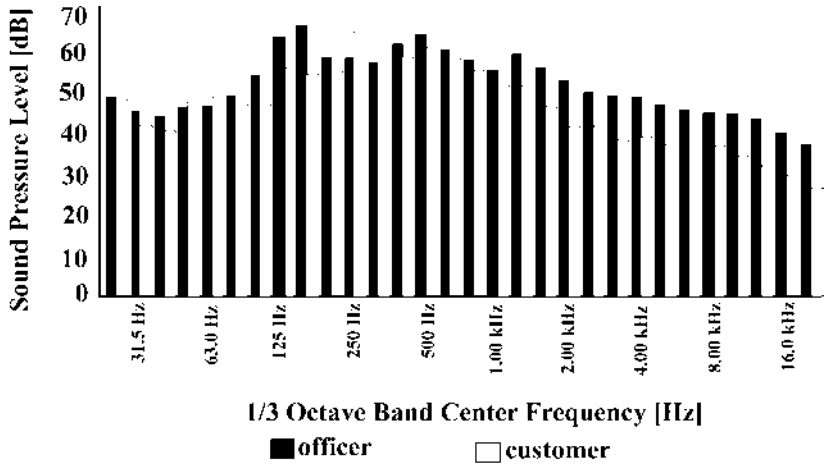


**FIGURE 2**
One-third octave-band sound levels across plexiglass barrier comparison.

room was reset by NIOSH investigators to cooling and fan mode (with a 72°F set point). The ventilation system responded by supplying air to the space and diluting $CO_2$ concentrations. At 10:10 a.m., despite a continued high room occupancy, the $CO_2$ concentration decreased to about 2000 ppm. Figure 4 shows this increase of $CO_2$ early in the day in the adjacent customer reception area. Note that the $CO_2$ concentrations decreased after about 9:40 a.m. due to the dilution affect from the provision of supply air.

At 11:30 a.m. the remaining thermostats were reset to the on position and fan mode, and the temperature set points were maintained at their existing settings. The temperature set points were 70°F in the investigations area and computer room, and 68°F in the records room. As shown in Table II, there is about a 4°F discrepancy between the temperatures measured by NIOSH and those shown on the thermostats in the computer room and investigations area. The thermostat in the records room was in good agreement with the NIOSH measurement.

Table II lists the temperature and RH results from the spot measurements taken throughout the day in several office areas. Figures 3 and 4 provide a graphical presentation of the continuous measurements made in the information officer reception area and customer side reception area, respectively. The indoor temperatures ranged from about 68 to 76°F; the RH ranged from about 24 to 40 percent. Most of the measurements fell within, but at the far end of ASHRAE's acceptable ranges of operative temperature and humidity for people in typical winter clothing (heavy slacks, long-sleeve shirt, and sweater). The acceptable ranges are based on a 10 percent dissatisfaction

**TABLE II**
Indoor environmental quality data

| Location | Time | Temp (°F) | RH (%) | $CO_2$ (ppm)[A] | Comments |
|---|---|---|---|---|---|
| Public waiting room | 9:03 | 72.4 | 40.1 | 3180 | 43 people (ventilation system off) |
| | 10:10 | 72.6 | 33.5 | 2002 | 48 people (ventilation system on at 9:10 a.m.) |
| | 11:39 | 72.0 | 33.6 | 1980 | |
| | 1:00 | 72.1 | 30.9 | 1375 | 16 people |
| | 2:00 | 71.6 | 29.8 | 1255 | 20 people |
| Room 120 | 8:58 | 71.3 | 26.9 | 662 | Private office, 1 person |
| | 9:55 | 72.5 | 25.5 | 820 | 3 people |
| | 10:55 | 73.0 | 23.7 | 715 | |
| | 12:47 | 68.4 | 29.6 | 915 | 1 person |
| | 1:47 | 70.8 | 30.2 | 1115 | 3 people |
| Investigations area | 11:30 | 72.0 | 31.8 | 1485 | Open work area, thermostat reads 68°F |
| | 12:50 | 69.4 | 31.4 | 1080 | |
| | 2:02 | 71.5 | 29.5 | 1250 | |
| Records room | 11:32 | 71.9 | 27.0 | 1300 | Thermostat reads 72°F |
| | 12:55 | 69.4 | 29.2 | 860 | |
| | 2:05 | 70.2 | 28.6 | 1100 | A lot of in-and-out traffic |
| Computer room | 11:35 | 68.5 | 26.9 | 1102 | Thermostat reads 64°F |
| | 12:55 | 69.4 | 29.2 | 860 | |
| Outside | 10:25 | 58.2 | 26.9 | 307 | |
| | 1:05 | 65.8 | 19.6 | 311 | Sunny and breezy |

[A]ppm = parts per million.

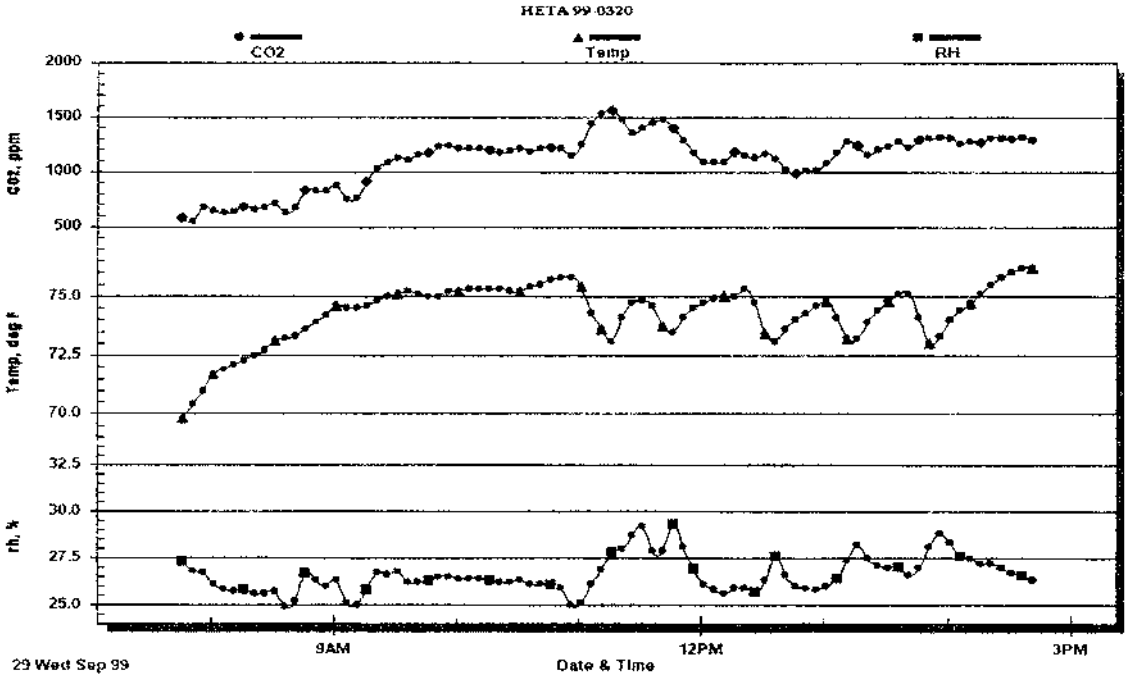


**FIGURE 3**
Indoor environmental quality data from information officer side reception area.

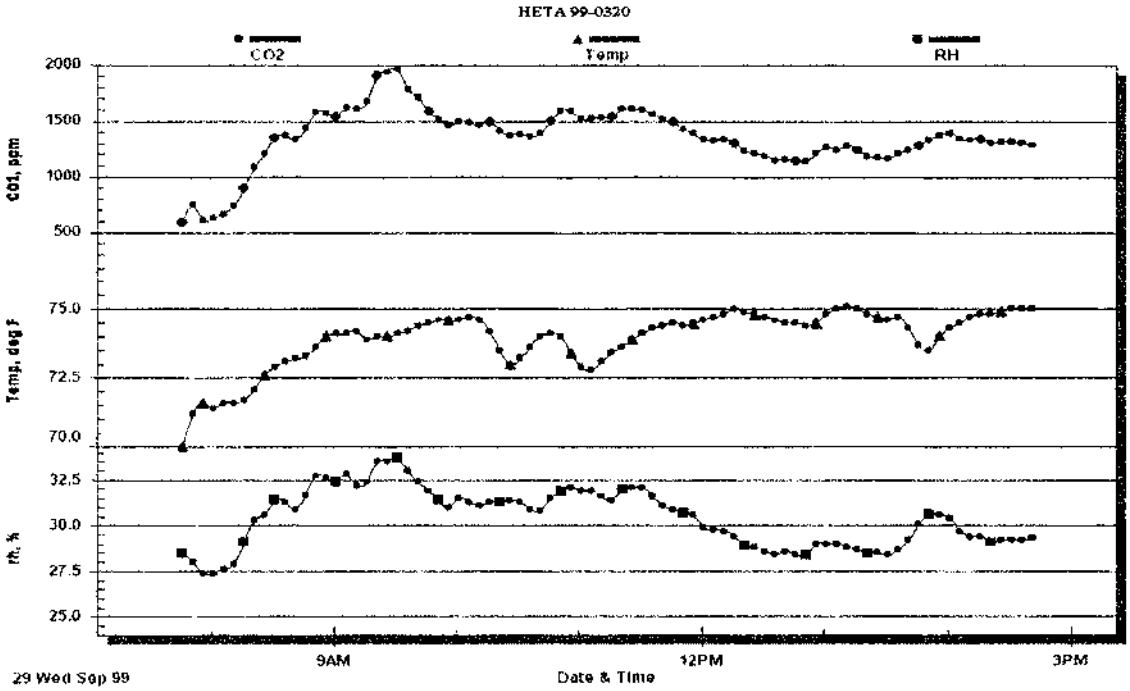


**FIGURE 4**
Indoor environmental quality data from customer side reception area.

criterion. Measurements that fell outside the acceptable ranges did so because of low RH. However, for persons dressed in typical summer clothing (light slacks and short-sleeve shirt) as might occur during this transitional season, the measurements generally fell outside the acceptable ranges due to a combination of low RH and relatively low air temperature.

Results of the air flow measurements are shown in Table III. Because additional information could not be obtained on the ventilation system, the NIOSH data could not be compared with design specifications or data from prior test and balance reports. The information does show, however, that the amount of outdoor air delivered to the waiting room does not meet current ASHRAE guidelines. Considering the maximum occupancy observed (48 persons) and the ASHRAE recommendation of 15 cfm of outdoor air per person in reception areas, 720 cfm of outdoor air would be needed to provide acceptable indoor air quality. The total air supplied to this room was only 645 cfm; the proportion of this amount that was outdoor air was unknown.

The smoke tube traces showed that the building was under positive pressure with respect to the outside. The waiting room was found to be under positive pressure with respect to the customer reception area, and the customer reception area was under positive pressure with respect to the information officer reception area and the adjacent corridor. Thus, air from the waiting room was mixed with air in the office areas. The degree of air mixing that occurred as a result of recirculation of air within the mechanical ventilation system was not known because ventilation system diagrams and specifications were not made available to the NIOSH investigators.

## Discussion

From an acoustical perspective, there were two different situations observed at the INS office. There was little sound isolation within the information officers' work area and the customers' reception area. Conversations and office noises reverberated throughout the two areas, leading to interference in speech understanding. However, the plexiglass barrier between the two areas was causing a loss of sound energy, particularly in the higher frequencies. This will lead to additional impact on communications between information officers and the public they are serving. The communication decrement further complicates the situation where there are language barriers that must be overcome between the officers and the customers. In some cases, the children of the customers were observed serving as interpreters for their parents. The fixed height of the hole in the plexiglass forced many of the smaller children to stand on tiptoes for their ears to be at the level of the information officer's mouth.

The metal, slotted covers that once were placed over the holes in the plexiglass barrier to reduce air movements between the reception and work areas further reduce communications between officers and their customers. There was no amplification system in the covers to boost the signals. It is assumed that this was one of the reasons that they had been removed by the time of the NIOSH site visit.

With respect to IEQ concerns, ventilation and comfort indicators were measured to assess current environmental conditions. Three of the four thermostats located in the areas of concern had been turned off; thus, there was no air being supplied to these areas. It is not known how long the thermostats had been off. Because of the relatively mild outdoor air temperatures at the time of the survey (58°F in the morning and 66°F in the afternoon), thermal comfort may have been acceptable to many occupants. However, after the thermostats had been turned on by the NIOSH investigators and set to the cooling mode with continuous fan operation (maintaining the existing temperature set points), complaints of being "too cold" were received from some employees. When compared with the ASHRAE guidelines for thermal comfort, most of the temperature and humidity measurements fell at the far ends of the acceptable ranges recommended for persons dressed in typical winter clothing, and were completely outside the acceptable ranges for persons dressed in typical summer clothing. Thus, it was not surprising that some employees reported thermal comfort complaints.

In addition to providing acceptable thermal comfort, mechanical ventilation systems are intended to provide acceptable indoor air quality by diluting (and removing) general contaminants and odors (bioeffluents). NIOSH investigators measured $CO_2$ concentrations in the office and waiting areas as an indicator of the adequacy of outdoor air supplied to occupied areas. In the waiting room where there was a high level of occupancy, $CO_2$ concentrations had risen to almost 3200 ppm by around 9:00 a.m. This $CO_2$ concentration was well in excess of 800 ppm, the concentration that NIOSH believes should trigger further evaluation of the ventilation system due to suspected inadequate

**TABLE III**
Airflow measurements

| Location | Total supply air (cfm)[A] | Total return air (cfm) |
|---|---|---|
| Information officers side reception area | 264 | 173 |
| Customer side reception area | 182 | 145 |
| Public waiting room | 645 | 362 |
| Private office, room 120 | 205 | 232 |

[A]cfm = cubic feet per minute.

ventilation. Although the $CO_2$ concentrations decreased in this and other areas after the thermostats were set to fan mode, $CO_2$ concentrations remained above 800 ppm throughout the evaluated area.

## Conclusions

The acoustical parameters measured during the NIOSH health hazard evaluation (HHE) showed that communications were difficult in the work area of the information officers. The ambient noise levels in the reception area were above the criteria developed for occupied spaces where communication is needed.[3] In addition to the less than optimal communication space, was the plexiglass barrier and fixed opening which reduced the sound levels of peoples' voices, making it more difficult to hear, particularly in the situation where language was an issue between the speaker and the listener. Based on these findings, the INS was advised to initiate action to see that changes were made in the room characteristics and in the way communicated information was passed between the officers and the public.

The IEQ evaluation indicated that more attention needed to be paid to the operation and maintenance of the ventilation system, and that the amount of outdoor air delivered to the waiting area should be increased. It was not clear from this limited evaluation to what extent recirculation of air from the waiting area contributed to the elevated $CO_2$ concentrations in other office areas.

It is generally not a good practice to completely turn off the ventilation system in an area, even if there is acceptable thermal comfort. This practice can lead to an increase of contaminants and odors, and can result in air stagnation. This is particularly important in areas where there is a high occupant density, such as in the customer waiting room and reception area. Informal discussions with employees revealed that thermostats were often adjusted or turned off completely, primarily because they were too cold. This suggests that temperature set points should be adjusted. The temperature and humidity levels that NIOSH investigators measured confirmed that the existing set points were not appropriate. ASHRAE guidelines can be used to determine the appropriate temperature set points that will result in minimal occupant dissatisfaction.[20,21] The low humidity levels in this area of the country would need to be considered in selecting appropriate temperature set points for different seasons.

## Recommendations

Based on the observations and measurements made during the HHE, the following recommendations were made to INS management to improve the conditions in the information officers' work area.

1. The listening conditions in the customer reception area were not conducive to the communication requirements for the space. The ambient noise levels needed to be reduced for the public to adequately hear the information the officers were giving them. Because the existing walls and floors were made of relatively hard materials (painted wall board, glass, and floor tiles), sounds generated in the room reflected off of these surfaces. Introduction of softer materials (carpet and draperies) will help to reduce these reflections. Also, much of the interfering noise was generated by the public conversing with the information officers. There was no separation between individual customers so that conversations to the side would disrupt the flow of information. Consideration should be given to adding barriers between each of the three customer stations. The barriers would have to be long enough and tall enough to block conversations between customers. At a minimum, the walls would have to completely separate the customers from each other to effectively block the sound. Temporary changes to the reception area would be made by INS or the building manager's maintenance staff to see if the recommended changes have a positive effect on the listening conditions in the room. However, an acoustical engineer may need to be consulted for the proper materials and design.
2. The round hole through the plexiglass did not allow for adequate communications. It was observed to be at an incorrect height for several customers and information officers. Since it was impossible to adjust the height of the opening in the plexiglass, it was recommended that an amplification system be installed. A model for the system is the headset/speaker configuration seen in most fast-food restaurants. The officers would have their own headset and microphone issued to them. Because hygiene would be an issue for the customers, a speaker or microphone is appropriate rather than a headset or telephone receiver. A system of this type would allow the INS officers to speak at a normal level without raising their voices and still be heard and understood by the public.
3. To ensure that outdoor air is being supplied to the office and waiting areas during occupied periods, the thermostats should be set to the fan mode and to heating or cooling, as appropriate. ASHRAE standard 55-1992, *Thermal Environmental Conditions for Human Occupancy*, should be used to determine appropriate temperature settings.[20]
4. The amount of outdoor air supplied to the waiting area should be increased. ASHRAE standard 62-1999, *Ventilation for Acceptable Indoor Quality*, recommends a minimum of 15 cfm of outdoor air per person in reception areas and 20 cfm of outdoor air per person in general office areas.[21] Outdoor air supply rates should be reviewed for

other office areas, and supply rates increased if necessary to meet the ASHRAE criteria.

5. Because of the intermittent and variable occupancy in the waiting room, it would be prudent to contact a qualified mechanical engineering firm for advice in selecting appropriate ventilation rates and the advisability of having a separate ventilation system dedicated to this area.
6. The thermostats should be calibrated to ensure accuracy of the readings and the thermal control system should be further evaluated. The 2–3°F temperature flux between demand and satisfied modes shown in Figure 3 may be contributing to thermal comfort complaints. If thermostats are replaced, consideration should be given to purchasing units without an off setting. At a minimum, the thermostats should be locked and access minimized to avoid unnecessary tampering.
7. A complete test and balance of the HVAC system should be performed after modifications are made to ensure that the system operates as intended. The test and balance should be performed by a qualified HVAC technician familiar with the system at the INS.

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**EDITORIAL NOTE:** Randy L. Tubbs, Ph.D. and Teresa Seitz are with the Hazard Evaluation and Technical Assistance Branch of the National Institute for Occupational Safety and Health. More detailed information on this evaluation is contained in Health Hazard Evaluation Report No. 99-0320-2791, and is available through NIOSH, Hazard Evaluation and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, OH 45226; telephone: 1-800-35-NIOSH; fax: (513) 533-8513.