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U.S. DEPARTMENT OF THE TREASURY,
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SUMMARY

On April 4, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request from Chapter 99 of the National Treasury Employees Union for a Health Hazard Evaluation at the Internal Revenue Service Brookhaven Service Center. The union was concerned about reportedly poor air quality in many office areas of the facility. NIOSH investigators conducted an initial medical and environmental survey on March 23 through 25, 1992, during which they inspected and evaluated the facility and portions of its heating, ventilating, and air-conditioning (HVAC) equipment, conducted informal, private medical interviews with 14 employees, and measured air temperatures, relative humidities, and carbon dioxide (CO_2) concentrations. Almost every indoor relative humidity level measured was below the minimum of 30% recommended in the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) ventilation standard. Also, a variety of physical factors (e.g., dirt, debris, and standing water inside some air handling units and/or potential problems with their condensate drains, potentially inappropriate time scheduling for the operation of some air-handling systems, open doorways between motor-vehicle loading docks and office areas, and other factors) that may impact the indoor environmental quality (IEQ) in the facility were found. Furthermore, most of those interviewed reported experiencing health symptoms (e.g., eye irritation, headache, fatigue, and others) and/or thermal discomfort while in the building.

The NIOSH investigators conducted a more-comprehensive follow-up survey on August 18 and 19, 1992, in the areas served by two selected air-handling systems in the facility, one serving the "RPS" area and part of the "Data Conversion Branch" in Building 2 and the other serving an area almost entirely occupied by the Adjustments Branch in Building 3. These areas contrast in their air-handling system configurations, and in the types of employee complaints reported and the environmental conditions measured during the initial survey. Questionnaires were distributed to employees asking if certain medical complaints and symptoms were experienced, and asking about their perception of the environmental conditions in the work area. Also, air temperatures, relative humidities, velocities (non-directional), and CO_2 concentrations were measured in numerous locations throughout the workday and (except for CO_2 concentrations) at multiple elevations from the floor.

A spectrum of symptoms similar to that typically found in IEQ evaluations was reported by the questionnaire respondents, with the most commonly reported being eye irritation or strain, headache, fatigue, nasal congestion, and dry or sore throat. Reported symptom prevalences for these and other, less frequently reported symptoms, were roughly the same in both areas, except for reported "work related" nasal congestion, memory difficulties, and shortness of breath which were significantly higher ($p < 0.05$; Fisher's Exact test) among Building 3 Adjustments Branch employees. Most of the environmental parameters measured were found to be within applicable guidelines, except for the temperatures in the RPS/Data Conversion area of Building 2.

There, measured temperatures ranged from 66°F to 74°F, and most were outside the desired range of 73°F to 79°F (for a relative humidity of 60%, which is similar to the measured relative humidity levels) recommended by ASHRAE for persons dressed in summer clothing. A combined evaluation of the following parameters suggests the possibility of marginal ventilation effectiveness in the Adjustments Branch area served by air-handling system (AHS) 301 in Building 3, due to the normal operation of its economizer control during warm or very cold weather and/or, perhaps, to less-than-adequate air mixing in the occupied spaces. These parameters are: HVAC-system configuration and operation information for AHS-301 (which is equipped with slot diffusers in 12-foot ceilings and the economizer control), the results of the environmental measurements made in that area (airborne CO_2 concentrations approaching the ASHRAE-recommended limit of 1000 parts per million (ppm), despite reduced occupancy), and (although subjective in nature) the questionnaire responses pertaining to perceived environmental conditions in the area (such as "too little air movement" and "too hot"). Additionally, air temperature measurements in the same area indicate the abnormal absence of vertical temperature gradients, also perhaps indicating less-than-adequate air mixing.

The results of this evaluation suggest that multiple factors -- the excessively cold measured temperatures, the excessively low measured relative humidities, the observed deficiencies regarding some air-handling systems, potentially marginal ventilation rates and/or air mixing, and others -- have impacted on the IEQ in this facility, making the causes of (and thus the solutions to) most of the reported complaints unclear. Except for the too-cold temperatures measured in the RPS/Data Conversion area in Building 2 during the August 1992 follow-up survey, the findings of this evaluation cannot confirm any of these factors as causative in relation to the employees' complaints and reported symptoms. Recommendations include: increasing the average temperature in the RPS and Data Conversion areas in Building 2; correcting observed deficiencies in several HVAC-system air-handling units (see Recommendations section); providing hot water to the reheat coils of AHS-301 to allow zone-by-zone thermostatic control during the warmer months in the Adjustments Branch (Building 3); and, reviewing certain design features (such as supply-air diffuser types and velocities, supply-air distribution flowrates and the resulting "effective" outside-air delivery rates, thermostat locations, and the use of a fully unducted return systems) of AHS-301 and other systems.

Keywords: SIC 9311 (Public finance, taxation, and monetary policy); indoor environmental quality; air temperature, relative humidity, thermal gradients, and ambient velocity; thermal comfort; ventilation rates; carbon dioxide.

BACKGROUND AND INTRODUCTION

On April 4, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request from Chapter 99 of the National Treasury Employees Union (NTEU) for a Health Hazard Evaluation (HHE) at the Internal Revenue Service North Atlantic Region's Brookhaven Service Center. The union, which represents much of the workforce at the Brookhaven facility, asked NIOSH to evaluate the indoor environmental quality (IEQ) in the facility due to workers' expressed concerns that the air quality was poor in many office areas of the facility.

NIOSH investigators conducted an initial medical and environmental survey at the facility on March 23 through 25, 1992. On June 4, 1992, letters summarizing the preliminary findings from the initial survey were sent to management and union representatives. Based on the preliminary findings, the NIOSH investigators conducted a more-comprehensive follow-up survey on August 18 and 19, 1992, in two selected areas of the facility. An interim report summarizing a portion of the HHE results was sent to management and union representatives on May 14, 1993.

FACILITY DESCRIPTION

GENERAL FACILITY AND HVAC DESCRIPTION

The primary function of the Brookhaven Service Center is to receive and process all Federal income tax returns for the entire North Atlantic Region of the United States. Employment at this 20-year-old facility is predominately female and ranges from a minimum of about 2500 to a maximum of 4700 people, due to seasonal variations in the work load. The facility has five interconnected buildings on a single level, with an approximate total floor space of 500,000 square feet (ft^2). Along with numerous income tax processing departments, a variety of support functions and areas, such as computer facilities, shipping and receiving, and food services for employees, are also contained in the complex. At the time of the NIOSH surveys, smoking was permitted in the building only in designated locations, such as the smoking "canteen" and the small (smoking) dining room.

The following details about the heating, ventilating, and air-conditioning (HVAC) system features apply throughout the building:

1. A central utility plant produces hot and chilled water for space heating and cooling. These media are produced with dual-fuel (gas or oil) steam boilers and steam-absorber powered water chillers, along with gas-powered and electric-powered water chillers.

2. Forty-one air handling systems (AHSs) condition (heat and cool) air using the hot and chilled water, and distribute the conditioned air to occupied spaces of the facility. Each AHS has an air handling unit (AHU) with a fan which moves the air to be conditioned through a set of filters and across chilled-water coils, and then distributes this "supply air" (SA) through a network of supply-air ducts and supply-air diffusers. Entering most of

the AHUs is a mixture of outside air (OA), and return air (RA) recirculated by a return-air fan from the occupied spaces through return-air grilles or slots and, in most cases, unducted plenums. In these AHSs, some of the returning air from the RA fan is discharged to the outdoors, and the combination of this discharge and the intake of OA effects ventilation (OA exchange) of the occupied spaces. A few of the AHSs recirculate no air; 100% OA enters their AHUs for conditioning and distribution, and air is exhausted from the occupied spaces and discharged outdoors (at a rate similar to that at which it is supplied to the spaces) by an exhaust fan which takes the place of a RA fan.

3. All 41 AHSs are "constant-air-volume" (CAV) types (the volumetric SA flowrate is constant) serving areas that are divided into "zones," with each zone served thermostat-controlled, hot-water-circulating reheat coils (during the heating season only) located in the SA duct network. However, since hot water is not circulated to the reheat units during the cooling season, zone-by-zone thermostatic control is not available during that time, and thermal control in the occupied spaces is achieved by varying the temperature of the SA delivered to the entire service area of a given AHS.

4. The AHUs which condition and supply a mixture of OA and RA have sets of automatically-controlled variable dampers which allow the system controls to vary the relative flowrates of the recirculating air, inducted OA, and discharged air. Minimum OA-intake rates are specified for the AHSs, and they have "economizer" controls which are designed to automatically increase the OA-intake rates above the specified minimums (by modulating the automatically-controlled variable dampers) when cool outside air is available to handle the heat load generated in the occupied spaces.

DESCRIPTION OF SELECTED AREAS AND AIR HANDLING SYSTEMS

Based on information obtained during the March 1992 initial survey of the facility, two contrasting areas were chosen for study in the follow-up survey of August 1992. The findings used to make this selection are subsequently described in the section of this report pertaining to the initial survey results and observations; the current section simply describes the two areas.

One of the two areas chosen was the space, in Building 2, served by the AHS that includes air-handling unit AC 204; this AHS will be referred to as AHS-204. The "Remittance Processing System (RPS)" area and part of the "Data Conversion Branch" occupy this space. This area was one of a few in the facility served by an AHS with a supply-air distribution plenum located beneath a false floor and SA diffusers mounted in floor panels. Much of this area had originally contained an extensive amount of 1970s-vintage electronic equipment, which produced heat at relatively high rates compared with most of the equipment in the area today. To cool this equipment, the HVAC system had been configured similar to those often found in computer rooms, with the below-floor SA-distribution plenum and floor-mounted supply-air diffusers. Return-air (RA) grilles are located in ceilings, and lead to unducted RA plenums. Reportedly, RPS/Data Conversion employment was 68 people during the August follow-up survey, and typically rises to approximately 300 people during the peak, spring season. However, most of the employees added at that time occupy space

in Building 2 immediately adjacent to that described above, but which is not served by AHS-204. This adjacent space, which had few occupants during the follow-up survey, is served by "AHS-205."

The other area chosen for study was the area of Building 3 served by "AHS-301" (the AHS that includes AC 301). Like the majority of the office space in the facility, the AHS-301 service area has 12-foot ceilings containing slot-type SA diffusers, and grilles leading to an unducted, above-ceiling RA plenum. This area is almost entirely occupied by the Adjustments Branch; conversely, the entire Adjustments Branch is located in this space. Reportedly, Adjustments Branch employment stood at approximately 205 people during the August follow-up survey, compared with approximately 250 people during the March initial survey.

EVALUATION CRITERIA

Indoor environmental quality is affected by the interaction of a complex set of factors which are constantly changing. Four elements involved in the development of IEQ problems are:

- sources of odors or contaminants,
- problems with the design or operation of the HVAC system,
- pathways between contaminant sources and the location of complaints,
- and the activities of building occupants.

A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

The symptoms and health complaints reported to NIOSH by non-industrial building occupants have been diverse and usually not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats, and other respiratory irritations. Usually, the workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[1-5] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of 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.[8-13] Indoor environmental pollutants can arise from either outdoor sources or indoor sources.

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related than any measured indoor contaminant or condition to the occurrence of symptoms.[14-16] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16-19]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building-related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, carbon monoxide poisoning, and reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by Legionella bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately ventilated kerosene heaters or other fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems NIOSH investigators have found in the non-industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from furnishings, 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; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, these problems could not be directly linked to the reported health effects.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[20-22] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[23,24] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related complaints that might be caused by airborne living organisms or their effluents.[25]

Measurement of indoor environmental contaminants has rarely been helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between contaminants and specific building-related illnesses. The low-level concentrations of particles and mixtures of organic materials usually found are difficult to interpret and usually impossible to causally link to observed and reported health symptoms. However, measuring ventilation and comfort indicators such as air temperature, relative humidity, and carbon dioxide (CO_2) concentration has proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The bases for measurements made during this evaluation are discussed below.

VENTILATION AND CARBON DIOXIDE

Carbon dioxide is a normal constituent of exhaled breath and monitoring its concentration in the air of an occupied indoor space may be useful as a screening technique to evaluate whether outside air is being introduced into the space at an adequate rate and/or distributed properly; thus the CO_2 concentration may serve as a secondary indicator of ventilation effectiveness. Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300 to 350 parts per million [ppm]). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation rates are suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased.

ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality," recommends ventilation (OA-exchange) rates of 20 cubic feet per minute (cfm) per person for office spaces and conference rooms, and 15 cfm/person for reception areas, and provides estimated maximum occupancy figures for each area.[23] Also, its "Multiple Spaces" section provides a method for calculating the proper OA-intake rates for central air-handling systems that serve multiple spaces to assure that the effective ventilation rate provided to each space at least equals the recommended rate. This Standard also recommends a limit of 1000 ppm for indoor CO_2 concentrations.

THERMAL COMFORT FACTORS

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1992 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[24] This Standard specifies the operative temperatures shown in the following box for persons dressed in typical summer clothing and winter clothing, and engaged in light activities, at the maximum- and minimum-recommended RH levels, respectively, of 60%[23,24] and 30%[23].

RECOMMENDED OPERATIVE TEMPERATURE RANGES
(from ASHRAE Std. 55-1992)

	At 60% RH	At 30% RH.
Typical Summer Clothing:	73°F to 79°F	74°F to 80°F
Typical Winter Clothing:	68°F to 74°F	69°F to 76°F

The air temperature within an occupied indoor space generally rises from floor to ceiling. To prevent local discomfort at the head or feet, Standard 55-1992 recommends a maximum vertical air-temperature difference of 5°F within the occupied zone (between 4 and 67 inches [in]) from the

floor). It also recommends that floor surface temperatures be between 65°F and 84°F for people wearing typical indoor footwear.

The Standard also addresses ambient, non-directional air velocity. No minimum air velocity is needed for thermal comfort, but a maximum of 40 feet per minute (fpm) is specified for persons dressed in typical summer clothing. If this level of movement is exceeded, air temperatures must be increased above the summer comfort zone by amounts which are specified in the Standard. No maximum air velocity is specified range for persons dressed in typical winter clothing, but the 30 fpm limit specified in the previous (1981) version of Standard 55 is implied to remain valid.

EVALUATION METHODS

MEDICAL EVALUATION

The initial medical survey in March 1992 primarily consisted of private interviews with 14 employees to discuss any health symptoms, irritation, or thermal discomfort experienced while in the building.

During the follow-up visit in August 1992, questionnaires were distributed on the first day (August 18) to all 49 RPS and Data Conversion Branch employees working that morning in the area served by AHS-204 in Building 2, and on the second day (August 19) to all 137 employees working *that* morning in the Adjustments Branch in Building 3. On each questionnaire was placed a code identifying the environmental monitoring location (to be subsequently discussed) nearest to the workstation of the employee to which it was distributed; this information allowed a subsequent evaluation of the relationship between reported complaints, measured environmental conditions, and the contrasting AHS configurations found in the two main areas, by contrasting the differences in findings for the vicinities of the monitoring locations, as well as for the two main areas.

The questionnaire asked if the employee had experienced, while at work on the day of the survey, any of 13 symptoms (irritation, nasal congestion, headaches, etc.) commonly reported by occupants of "problem buildings." The questionnaire also asked about the frequency of occurrence of these 13 symptoms while at work during the four weeks preceding the survey, and whether these symptoms tended to get worse, stay the same, or get better when they were away from work. The final section of the questionnaire asked about environmental comfort (too hot, too cold, unusual odors, etc.) experienced while the employees were working in the IRS facility during the four weeks preceding the questionnaire administration.

ENVIRONMENTAL EVALUATION

The initial environmental survey consisted of a facility inspection and an evaluation of building HVAC systems, including measurements of environmental parameters affected by HVAC-system performance. These parameters are air temperature, relative humidity, and CO_2

concentration (a secondary indicator of actual ventilation effectiveness). CO_2 concentrations in the air were measured using an electronic, direct-reading GasTech RI411A CO_2 Meter with infrared detection. Simultaneous measurements were also made occasionally with the Dräger detector-tube system (specifically, a hand-held bellows pump and colorimetric, length-of-stain 0.01%/a CO_2 detector tubes were used). Air temperatures and RHs were measured using a Vaisala HM34 meter. Simultaneous measurements were also made occasionally with an Environmental Tectonics Corporation Psychro-Dyne automatic psychrometer with two mercury-containing glass thermometers (one wet and one dry bulb).

The CO_2 concentrations, temperatures, and RHs were measured in seven locations throughout the facility, and outdoors as well. These parameters were measured twice during the workday in most locations.

The follow-up environmental survey primarily involved numerous measurements of four environmental parameters affected by HVAC-system performance, the three mentioned above along with ambient air velocity. During the follow-up survey, CO_2 concentrations in the air were measured using only the GasTech CO_2 Meter, while air temperatures and RHs were measured using only the Vaisala meters. Ambient air velocities were measured with two types of heated-sphere, omnidirectional anemometers.

The CO_2 concentrations, temperatures, RHs, and ambient velocities were measured on the first day of the follow-up survey at nine locations in Building 2, throughout the RPS area and the parts of the Data Conversion area located within the AHS-204 service area, and on the second day at ten locations in the Adjustments Branch in Building 3. Measurements were repeated three times during the day for temperatures and RHs, twice for velocities, and six times for CO_2. To assess thermal gradients and/or perceived gradients due to velocity variations, air temperatures, RHs, and velocities were measured at selected, multiple height levels above the floor. Specifically, temperatures and RHs were measured near the floor and about 4 feet (ft) above the floor, while the velocities were measured near the floor, and about 4 and 7 ft above the floor. The outdoor CO_2 concentration, temperature, and RH also were measured each day.

RESULTS AND OBSERVATIONS; DISCUSSION

MEDICAL EVALUATION

During the initial site visit, private medical interviews were conducted with 14 employees from nine branches located throughout Buildings 2, 3, and 4. Of these employees, 13 (10 bargaining-unit members referred by the NTEU and 3 non-members referred by management) had expressed a desire to speak with the NIOSH medical officer. An interview was requested by the NIOSH medical officer with one additional bargaining-unit employee to gain further information regarding health and comfort concerns in one branch. Total employment at the facility during the survey was about 3200 people.

Most of the interviewed employees reported experiencing health symptoms or thermal discomfort while in the building. Specifically, frequent headaches were reported by six, frequent eye irritation by seven, frequent nasal congestion by two, frequent fatigue at work by six, and impaired ability to concentrate by three. Four employees suffered from asthma (two felt that being in the building did not influence their symptoms, while two felt their symptoms tended to be worse when in the building). Ten of the employees reported frequently experiencing thermal discomfort while working in the building. Five felt that their workstations alternated between being too cold and too hot (and seldom was just right), four felt their workstations were mainly too cold, and one felt that the workstation was usually too hot. Employees also reported the occasional occurrence of strong odors within the building. The odor of "dead mice" beneath the subfloor in Building 3, diesel exhaust from the loading dock in Building 3, and strong cleaning solutions were three of the odors mentioned. Many of the employees interviewed mentioned frequently experiencing a feeling of a lack of fresh air. Several mentioned that the janitorial staff usually uses only a dry mop when dusting the office floors, consequently raising much dust during the cleaning process which engenders symptoms in some of the respondents.

During the follow-up visit in August 1992, questionnaires were distributed on August 18 to all 49 RPS and Data Conversion Branch employees working that morning in the area served by AHS-204 in Building 2, and on August 19 to all 137 employees working *that* morning in the Adjustments Branch in Building 3. Since 68 and approximately 205 employees, respectively, were reportedly employed by these Branches at the time of the survey, some individuals apparently were on leave status, attending to business outside of the immediate work areas, and/or otherwise not available during questionnaire distribution. Of the 49 questionnaires distributed to Building 2 employees, 47 (96%) were returned; of the 137 questionnaires distributed to Building 3 employees, 127 (93%) were returned.

The questionnaire results are shown in Tables 1 through 6. Table 1 shows the percentages of respondents among Building 2 (RPS/Data Conversion) and Building 3 (Adjustments Branch) employees who reported the occurrence of symptoms while at work on the day of the survey (August 18, for Building 2, and August 19, for Building 3). The employees from both areas reported notable prevalences of many symptoms, especially eye irritation or strain, headache, fatigue, nasal congestion, and dry or sore throat. Symptom prevalence is roughly the same in both areas.

Table 2 shows the percentage of respondents who reported experiencing the respective symptom once a week or more often while at work during the four weeks preceding the follow-up survey. These prevalences are similar to those experienced on the day of the survey and, except for nasal congestion, memory difficulties, and shortness of breath, are roughly similar for both areas.

Table 3 shows the percentage of respondents who reported experiencing the respective symptom once a week or more often while at work during the four weeks preceding the follow-up survey and also reported that the symptom tended to get better when they were away from work. This latter criterion has, in some studies of indoor environmental quality, been used to define a "building-related" symptom, but it is possible that a symptom which does not usually improve when away

from the building could also be due to conditions at work. The reported work-related frequent symptom prevalences are again highest for eye irritation or strain, headache, fatigue, nasal congestion, and dry or sore throat. For most symptoms the prevalences are similar in the two areas, but reports of frequent nasal congestion, memory difficulties, and shortness of breath are significantly higher ($p < 0.05$; Fisher's Exact test) among Building 3 Adjustments Branch employees.

Table 4 shows the number of employees who reported one or more symptoms that occurred at work at least once a week and that tended to get better when away from work. Of the 47 Building 2 RPS/Data Conversion respondents, 34 (72%) reported experiencing one or more such symptoms; 105 (83%) of the 127 Building 3 respondents did likewise.

Table 5 shows results of employee reports regarding environmental conditions at their workstations on the day of the survey. It shows that substantially more individuals in Building 2 reported excessive air movement and being too cold during at least part of the work day, and that substantially more employees in Building 3 reported sensing too little air movement and being too hot.

Table 6 shows the responses to the questions about environmental comfort experienced in the facility during the four weeks preceding the follow-up survey. Adverse environmental conditions (too hot, too cold, odors, etc.) were considered reportable if they occurred at work "frequently" during the four week period, which was defined as at least once a week or more often. The results are similar to those shown in Table 5 for work-station environmental conditions during the day of the survey, with the exception, among Building 3 Adjustments Branch employees only, of reduced reporting of being too hot and increased reporting of being too cold during the four weeks prior to the evaluation.

During the follow-up visit in August 1992, the NIOSH medical officer encountered several employees who reported experiencing frequent musculoskeletal discomfort in their backs, necks, and/or wrists while using personal computers at work. These employees frequently used personal computers for long periods, but lacked the ergonomic furnishings (wrist rests, adjustable chairs, and computer tables) needed to do so safely.

ENVIRONMENTAL EVALUATION, INITIAL SURVEY (MARCH 1992)

During the initial survey, the NIOSH investigators noted the following environmental factors which may impact on the IEQ at the Brookhaven Service Center:

1. In numerous locations in the facility, ceiling panels were observed that show discoloration and other evidence suggesting past water damage. Wet, porous materials are undesirable because they may provide favorable sites for microbial growth.

2. In Building 3, the doors between the loading dock and the Automated Under-Reporting Branch area were strapped open, even though they were not in use. Similarly, in Building 1, the

doorway between the loading dock and the machine service area was covered by a "curtain" of multiple, clear-plastic strips, some of which were broken. Other doorways to this dock also had similar plastic curtains along with ordinary, hinged doors; both types of barriers were propped open. Reportedly, the potential for entry of vehicle engine-exhaust emissions from the loading docks to adjacent spaces is of concern to some employees.

3. In the computer room, located in Building 2, accumulated dust was responsible for poor footing in some spots.

4. Standing water was observed in the condensate-tray area of one of the AHUs, AC 302. It was not clear what the source of this water was, since the cooling coils were not chilled at the time of the survey. In another AHU, AC 304, accumulated debris was observed between the pre-filter and main filter. In AC 202, old, deteriorated insulation was observed laying on the floor of the unit under the fan. In AC 305, what appeared to be old, water-damaged insulation was observed in a similar location, and considerable corrosion was observed under its cooling coils. Also, many of its interior surfaces in the vicinity of the cooling coil and fan appear to have been wet in the past. This also may be true of AC 207. All these types of conditions are undesirable because they may provide favorable sites for microbial growth inside these AHUs. In AC 306, loose insulation was observed on the fan-access door; this might fray, disseminating particles into the airstream.

5. The condensate-drain traps for AC 301 and AC 202 were dry, allowing odors or other potential air contaminants to be sucked into the AHUs through the drains. Also, the condensate-drain discharge pipe for AC 202 was tilted upward, instead of downward toward the floor drain as it should be. This may inhibit drainage, perhaps leading to standing water in the condensate tray during the cooling season.

6. The door to the mixed-air chamber (where outside and returned air are mixed) of AC 207 was chained open, while the outside-air intake damper was shut. Therefore, this AHU was not inducting any outside air and no ventilation (outside-air exchange) was being provided to the spaces it serves.

7. The schedules and procedures used by technicians in the facility's Total Energy Plant to determine the times of day when AHSs should be shut off and re-started (which they do using the computerized control system) reportedly were not always followed. Specifically, system operating procedures, as described to the NIOSH investigators during the initial survey, direct that any individual AHS is to be shut down for the night only when no one is in its service area, but apparently this restriction is sometimes disregarded. Also, the re-start of any systems that are shut down for the night was scheduled for 6:00 a.m., but some employees reported that they often arrive for work by then and perceive that the air already feels stagnant at that time.

Based upon the air temperature and RH measurements made in nine areas during the initial survey (see Table 7), the thermal comfort criteria (winter) recommended by ASHRAE generally

were not met during the survey, due in all but one case to low measured RHs rather than to the measured temperatures. Low indoor relative humidities are not unusual during the heating season in buildings without artificial humidification, and the NIOSH investigators doubt that the RHs which were slightly below the ASHRAE comfort zone account for many of the thermal-comfort complaints received during the survey. In contrast, the investigators suspected that insufficient or excessive air movement, which also affects thermal comfort (but which was not measured at that time), accounted for some of the complaints.

The measured airborne concentrations of carbon dioxide during the initial survey (see Table 7) were not elevated, compared to the guideline of 1000 ppm specified in ASHRAE™ Standard 62-1989. However, the operation of the AHSs' "economizer" controls -- designed to automatically increase the AHUs' outside-air-intake rates above the specified minimums when cool outside air is available to handle the heat load generated in the occupied spaces, thereby increasing ventilation rates (OA-exchange rates) to the occupied spaces also -- was expected to have resulted in greater-than-minimum ventilation rates during the initial survey, when the measured outdoor temperatures were around 50°F. The NIOSH investigators inspected nine AHUs, of which eight had economizer controls and variable outside-air-intake dampers; in six of these eight, the dampers appeared to be open beyond the minimum position, as was expected. During colder or warmer weather the economizer controls will automatically close the outside-air-intake dampers to their minimum-airflow positions, reducing ventilation rates and likely leading to CO_2 levels higher than those measured (assuming similar occupancy levels). Only one area evaluated during the initial survey, the Adjustments Branch area of Building 3, was re-evaluated during the follow-up survey (see the subsequent description of the follow-up survey environmental results and discussion), providing data from both time periods to allow a direct comparison of CO_2 levels.

Considering these findings along with the preliminary medical findings, questions persisted about the effectiveness of air distribution and mixing by the HVAC systems, in terms of ventilation and thermal control, and about air velocities and their effect upon thermal comfort. Numerous factors were identified which may <u>possibly</u> have adverse impacts on air velocities and/or on the effectiveness of air distribution and/or mixing. These included the following: high ceilings; supply-air diffuser types; changes in space utilization, and the addition and/or movement of partitions and other barriers over time without corresponding HVAC-system changes (to such things as supply-air flowrates, "effective" outside-air delivery rates, and thermostat locations); under-floor supply-air plenums in some locations; and, fully unducted returns. The NIOSH investigators determined that a further evaluation (requiring a follow-up visit) was appropriate, to characterize the effect of these factors upon air distribution, mixing, and velocities. The follow-up survey involved two contrasting areas of the facility and included a further evaluation of HVAC-system effectiveness coupled with a more extensive study of medical symptoms and complaints. The two selected areas were chosen as follows:

1. One area selected for follow-up study was the service area of AHS-204, which is the part of Building 2 that houses the RPS and part of the Data Conversion Branch area. The initial survey revealed that in this area, the employees' complaints focussed almost entirely upon thermal-comfort problems -- specifically, that the area was chronically too cool. This area

also was one of a few in the facility served by an AHS with a supply-air distribution plenum located beneath a false floor and SA diffusers mounted in floor panels, and those areas were unique because they seemed to generate the only consistent "chronic coolness" complaints. The AHS-204 service area was chosen for study to represent these areas (and to contrast with most other areas, where workers rarely complained of chronic coolness). The NIOSH investigators postulated that cool floor surfaces (due to the presence of cool supply air under the floor) and the introduction of cool supply air from floor-mounted diffusers tended to excessively lower the air temperatures and raise the air velocities around the seated workers' feet and legs.

2. In most areas of the facility, workers voiced a variety of IEQ complaints that often included "stagnant air" and "stuffiness" and that rarely included chronic coolness. Also, the majority of the office space in the facility has 12-foot ceilings containing slot-type SA diffusers, and grilles leading to an unducted, above-ceiling RA plenum. The other area chosen for study, to represent these more typical office spaces and to contrast with the RPS/Data Conversion area and areas like it, was the AHS-301 service area in Building 3, primarily housing the Adjustments Branch. This area is typical of most areas in the facility in terms of complaints reported, and in terms of its air distribution configuration -- it has the 12-foot ceilings with slot-type SA diffusers and the grilles leading to an unducted, above-ceiling RA plenum. Insufficient air movement at the occupants' level and poor air distribution and mixing were suspected due to this configuration.

ENVIRONMENTAL EVALUATION, FOLLOW-UP SURVEY (AUGUST 1992)

The results of the environmental monitoring conducted on August 18, 1992, in the area served by AHS-204 in Building 2 (RPS/Data Conversion area), are shown in Table 8, while those for the monitoring conducted on August 19 in the space served by AHS-301 in Building 3 (Adjustments Branch) are shown in Table 9.

Relative humidity results were very consistent, all falling between 53% and 64%, and were within or very near ASHRAE guidelines. Small RH changes, such as those within the range measured in this study, have little effect on thermal comfort,[24] so RH will not be further considered in this discussion.

The temperatures measured in the RPS/Data Conversion area of Building 2 were mostly too cold compared with ASHRAE guidelines for summer clothing; however, many employees there were more-warmly dressed. The data indicate these employees were being subjected to a temperature gradient with colder conditions near their feet. However, the gradient was not excessive according to ASHRAE guidelines. The temperatures in the Adjustments Branch area of Building 3 were nearly all within ASHRAE guidelines. However, the lack of any vertical temperature gradients in this area is actually abnormal,[24] and may indicate a lack of mixing of the cool SA from the slot diffusers in the ceiling to the lower, occupied zone.

All CO_2 concentrations measured in RPS/Data Conversion (see Table 8) were well within ASHRAE guidelines, indicating that the ventilation effectiveness provided by AHS-204 was very good for the number of employees (47) working there on the day the measurements were made. Although at other times more employees, perhaps well over 70, will occupy the AHS-204 service area, the data do not suggest a need for an increased effective ventilation rate during periods of increased occupancy levels in the area.

The CO_2 concentrations measured in the Adjustments Branch (see Table 9) also were within ASHRAE guidelines, but the levels tended to rise to peak levels twice during the day the measurements were made, before noon especially (when they ranged from 775 to 900 ppm) but also near the end of the workday to a lesser degree. The Branch staff left the area to attend an all-hands meeting elsewhere in the facility at 1317 (1:17 p.m.), and was out of the AHS-301 service area for about 25 to 30 minutes. It is plausible that, had the employees remained in the area throughout the afternoon, the measured CO_2 concentrations would have returned to the peak levels measured before lunch, or perhaps even higher. According to the information that the NIOSH investigators received during the follow-up survey, AHS-301 operates 24 hours per day except on weekends. This may allow it to "purge" the space of built-up CO_2 during periods of lower occupancy, returning the CO_2 concentrations to lower levels by morning than otherwise possible. Outdoor air temperatures dropped to approximately 55°F the night before the measurements were made, so the economizer control for AHS-301 is presumed to have increased the ventilation (outside-air exchange) rate, perhaps further reducing the CO_2 concentrations before the employees entered the area in the morning. At times during the summer months the overnight low temperatures outdoors will not drop low enough for the economizer to increase the ventilation rate in the area. Furthermore, apparently less than 150 of the estimated 205 Branch employees were working in the area on the day of the survey; had there been more, higher CO_2 concentrations may have been measured.

Because of the above three factors -- staff-meeting attendance, economizer operation, and below-normal occupancy -- it is plausible that, during the summer months when the daytime occupancy of the Adjustments Branch area is about 205 people, the CO_2 concentrations at a few locations there may at times meet or slightly exceed the 1000 ppm guideline, even though this did not occur during the survey. In comparison, occupancy of the area during the March 1992 initial survey was slightly higher, about 250 people, and the CO_2 concentration, measured between pillar 3-A-13 and 3-B-13, was 775 ppm in both mid-morning and mid-afternoon (see Table 7). This level is similar to those measured in that vicinity during the follow-up survey; as described previously, economizer-control operation was presumed to have provided greater-than-minimum ventilation rates during the initial survey, perhaps offsetting the greater occupancy level at that time.

The measured air velocities are generally within ASHRAE guidelines. In Building 2 (RPS/Data Conversion), they ranged from 6 to 34 fpm, with a mean of 17.5 fpm. In Building 3 (Adjustments), they ranged from 9 to 55 fpm, including the monitoring location near pillar 3-A-11, which was near a fan, where the measurements ranged from 39 to 55 fpm. Excluding that location, they ranged from 9 to 50 fpm, with a mean of 22.3 fpm, and only one other measurement (of 50 fpm) exceeded 36 fpm.

During the follow-up survey, facility management reported that many of the problems with the physical condition of various AHUs observed during the initial survey, enumerated in items 4 and 5 of the earlier initial-survey environmental discussion, had been corrected. The NIOSH investigators did not attempt to comprehensively re-evaluate these conditions during the follow-up survey.

The NIOSH investigators observed seemingly good compliance by the facility's workforce with the smoking policy permitting smoking in the building only in designated locations. The effectiveness of the smoking rooms and their ventilation systems in isolating cigarette smoke from neighboring areas and air-handling systems was not systematically determined. However, the investigators observed that cigarette smoke from the smoking canteen between Buildings 2 and 3 (near pillars 2-H-14 and 3-A-7, respectively) frequently moved out of the canteen into the connecting, enclosed breezeway. Many employees frequently use this breezeway to walk between work areas and to the dining rooms.

COMPARISON: PERCEIVED AND MEASURED ENVIRONMENTAL FACTORS, FOLLOW-UP SURVEY (AUGUST 1992)

The questionnaire responses to certain questions regarding workplace conditions on the day of the survey (specifically, those questions regarding air movement, temperature, and humidity), which are displayed for the individual monitoring locations of Buildings 2 and 3 in Tables 10 and 11, respectively, and the results of the environmental measurements (Tables 8 and 9) were together examined for relationships between those responses and the monitoring results among the individual monitoring locations. Little evidence of such trends or relationships among the individual monitoring locations of either Building is apparent from the information in these four Tables. Clearly discernable trends and relationships may not be apparent in this instance for one of two possible reasons. The first is that few or no such relationships truly exist among this group of individual monitoring locations. The second is that such relationships are obscured by wide variability among questionnaire respondents' perceptions combined with relatively small numbers of respondents from each monitoring location. Only 1 to 12 respondents (average, 5) worked near each monitoring location in RPS/Data Conversion (Building 2), and only 0 to 22 (average, 13) worked near each location in the Adjustments Branch (Building 3).

In contrast to these findings from the examination of the data for the individual monitoring locations, some relationships between the questionnaire responses and the measurement results could be discerned when the responses and environmental measurements were pooled for the two work areas (RPS/Data Conversion, with 47 questionnaire responses, and the Adjustments Branch, with 127 responses) and similarly examined for contrasting trends between them. Therefore, the subsequent discussion focusses on the observed trends when the results from the two buildings are compared.

The RH results (described previously) did not correlate with the perceived humidity of the air (the questionnaire responses are summarized in the following box); most occupants complained that the

air was "too dry" when, in fact, the measured RHs were in a comparatively narrow band near the humid end of the acceptable range recommended by ASHRAE.

QUESTIONNAIRE RESPONSES: HUMIDITY (from Table 5)

	"too humid"	"too dry"
Building 2 (RPS/Data Conversion):	23%	49%
Building 3 (Adjustments Branch):	30%	54%

The above responses, with substantial proportions of people in each area indicating opposite perceptions, are consistent with research indicating that most individuals are not good judges of RH,[26] and may simply indicate a more general dissatisfaction with the overall thermal conditions. Conversely, RH itself is unlikely a factor in the thermal comfort questionnaire responses provided in the following box.

QUESTIONNAIRE RESPONSES: TEMPERATURE (from Table 5)

	"too hot"	"too cold"
Building 2 (RPS/Data Conversion):	26%	72%
Building 3 (Adjustments Branch):	77%	27%

The dramatic contrast shown in this box is likely attributable to multiple environmental factors, the foremost of which of course is air temperature itself. Other possible factors, subsequently discussed, are vertical thermal gradients and perceived stagnation due to marginal ventilation effectiveness. The temperature measurements are summarized in the following box.

SUMMARY OF TEMPERATURE MEASUREMENTS (see Tables 8 and 9)

Building 2 (RPS/Data Conversion):
- approx. 4 ft.: 70 to 74°F, average 72°F (mostly 71 to 73°F)
- near floor: 66 to 71°F, average 70°F (mostly 69 and 70°F)
- difference: upper always exceeded lower, by a mean of 2°F

Building 3 (Adjustments Branch):
- difference between vertical (height) levels: virtually none
- 72 to 76°F, average 75°F (all but one measurement ranged from 73°F through 76°F)

The temperatures in Building 2 were mostly too cold compared with ASHRAE guidelines for summer clothing; however, many more-warmly dressed occupants still complained. However, they were also being subjected to a temperature gradient with colder conditions near their feet, although this gradient was not excessive according to ASHRAE guidelines. The results for the gradients and actual temperatures, considered together, are reasonably consistent with the questionnaire responses. The temperatures in Building 3 were nearly all within ASHRAE guidelines, but occupants complained that it was too hot. The abnormal lack of cooler air near the floor, in the absence of any vertical temperature gradients in Building 3 (perhaps indicating poor mixing of the cool SA from the ceiling diffusers to the lower, occupied zone), could contribute to the reported perception of elevated air temperatures.

The CO_2 measurements are summarized in the following box.

SUMMARY OF CARBON DIOXIDE MEASUREMENTS (see Tables 8 and 9)

Building 2 (RPS/Data Conversion):	425 to 575 ppm
Building 3 (Adjustments Branch):	500 to 900 ppm (600 to 900 ppm if one monitoring location excluded)

The CO_2 concentrations measured indicate that the ventilation effectiveness of AHS-301 in the Adjustments Branch in Building 3 was less than that of AHS-204 in the RPS/Data Conversion area in Building 2. All measured levels were within ASHRAE guidelines, but in Building 3 the levels tended to rise to peak levels approaching the ASHRAE limit before noon and near the end of the workday. The NIOSH investigators suspect that the comparatively lower ventilation effectiveness of AHS-301 in Building 3 may have contributed to a perception of "stagnant" or "stuffy" air, and that this perception in turn may result in more complaints of "too hot." The aforementioned, suspected less-than-adequate distribution and/or mixing of the SA, which is partially composed of outside air for ventilation, may be (if either indeed occur) partly responsible for the lower ventilation effectiveness of this AHS compared to that of AHS-204.

The air movement results do not immediately clarify the picture. Despite the thermal-comfort responses summarized above, Building 3 averaged greater air movement. (The air velocity measurements were summarized previously; the measured velocities were generally within ASHRAE guidelines.) The questionnaire responses (summarized in the following box) are not very consistent with these results.

QUESTIONNAIRE RESPONSES: AIR MOVEMENT (see Table 5)

	"too much"	"too little"
Building 2 (RPS & D. C.):	23%	55%
Building 3 (Adjustments):	9%	86%

The perception of too little air movement in Building 3, even though there apparently is "enough" (according to the ASHRAE guidelines), perhaps can also be explained as consistent with a "stagnant" or "stuffy" perception that has previously been discussed.

CONCLUSIONS

The results of this evaluation suggest that multiple factors have impacted on the IEQ in this facility, making the causes of (and thus the solutions to) most of the reported complaints unclear. The lower-than-recommended temperatures measured in the RPS/Data Conversion area of Building 2 are consistent with the results of the questionnaire survey in which RPS/Data Conversion employees frequently reported being too cold while at work. Although there otherwise were no clear environmental causes for the complaints and symptoms reported by employees, the NIOSH evaluation identified several other environmental deficiencies in the facility which may also be factors affecting the IEQ. These additional factors include:

1. The seven potential problems reported and/or visually observed during the March 1992 initial survey, previously enumerated in this report's initial-survey environmental discussion.

2. Low RHs in the winter.

3. Possibly marginal ventilation effectiveness in the Adjustments Branch area served by AHS-301 in Building 3, due to the normal operation of the economizer control during warm or very cold weather and/or, perhaps, to less-than-adequate air mixing in the occupied spaces. Additionally included is the abnormal absence of vertical temperature gradients in Building 3, also perhaps due to less-than-adequate air mixing.

4. Potentially less-than-adequate ventilation effectiveness in other areas besides those served by AHS-204 or AHS-301, due to minimum outside-air-intake rates inappropriate for current area occupancies along with the normal operation of the economizer controls during warm or very cold weather, and/or to possibly inadequate air mixing in the occupied spaces.

5. Potential ergonomic problems, due to lack of furnishings ergonomically appropriate for prolonged personal computer use.

6. Inadequate containment of tobacco smoke within at least one designated smoking area, the smoking canteen between Buildings 2 and 3, by the ventilation system serving the room.

The findings of this evaluation cannot confirm any of these factors as causative in regard to the employees' complaints and reported symptoms. The findings illustrate the difficulty sometimes encountered in the evaluation of IEQ complaints and the interpretation of IEQ data.

RECOMMENDATIONS

Based on the results and observations of this evaluation, the following recommendations are offered to correct the noted environmental deficiencies and optimize employee comfort.

1. During the initial survey, the NIOSH investigators noted seven environmental factors which may impact on the IEQ at the Brookhaven Service Center; these were fully explained in this report's initial-survey environmental discussion. Reportedly, some of these problems have already been corrected. The following recommendations, which were included in the interim letters of June 4, 1992, address the seven factors, and those recommendations that have yet to be implemented should be in the future:

    a. In each of the locations of the facility where discolored or damaged ceiling panels suggests past water damage, the area above the ceiling should be inspected for signs of current water leaks and condensation, as well as for evidence of microbial growth from excessive moisture. This is of particular importance because the area above the ceiling serves as a plenum for air returning to the AHUs. Any problems should be corrected, then the damaged ceiling panels should be replaced and the discolored panels cleaned or replaced.

    b. Barriers for the doorways to the loading docks in Buildings 1 and 3 should be kept in good repair, and should be allowed to close off the openings when the doorways are not in use.

    c. In the computer room in Building 2, improved housekeeping is needed to keep toner dust from the printers from accumulating on the floor. Accumulated dust was responsible for poor footing in some spots.

    d. The cause of the standing water observed in the condensate-tray area of AC 302 should be corrected. This AHU should be checked for chilled-water and/or hot-water leaks, and the condensate drain should be checked for blockage. Accumulated debris, corrosion, and loose, water-damaged and/or old insulation observed in AC 304, AC 305, and AC 202 should be removed, and the condensate drains of AC 305 and AC 207 should be checked for blockage since their interiors in the condensate tray area may have become wet in the past. In AC 306, the loose insulation observed on the fan-access door should be secured or removed. The NIOSH investigators were informed during the follow-up survey that the AHUs mentioned in this recommendation had been cleaned in the interim, but they did not re-inspect these AHUs.

    e. The condensate-drain traps for AC 301 and AC 202 should be filled with water, and a schedule should be established to assure that all condensate-drain traps, as well as the traps in the floor drains beneath the condensate-drain discharge pipes, are kept filled with water. Also, the condensate-drain discharge pipe for AC 202 should be changed to tilt downward toward the floor drain.

f. The door to the mixed-air chamber of AC 207 should be shut and the outside-air damper returned to normal operation, and any problems which may have caused the operating personnel to chain the door open and shut the outside-air damper should be determined and eliminated.

g. The schedules and procedures used by technicians in the facility's Total Energy Plant to determine the times of day when AHSs should be shut off and re-started (which they do using the computerized control system) should be reviewed and, if necessary, revised. Since most of the systems that are shut down for the night are re-started at 6:00 a.m. but, reportedly, some employees often arrive for work by then, the lead- and lag-time schedules may need revision. (The NIOSH investigators were informed during the follow-up survey that one system, AHS-204 in Building 2, serving RPS/Data Conversion, is re-started at 5:30 a.m.) For details on proper ventilation-system lead and lag times, refer to Section 6.1.3.4, "Intermittent or variable occupancy," of ASHRAE™ Standard 62–1989.[23] Building management should then reaffirm that the established schedules and procedures should be followed, particularly the system operating procedure directing that any individual AHS is to be shut down for the night only when no one is in its service area.

2. For the service area of AHS-204 in Building 2 (RPS and Data Conversion areas), the average temperature should be increased during the warmer months so that it is within the ASHRAE-recommended range. If problems persist, the AHS configuration may need to be changed to better suit the current use of the space. These changes may include revisions to eliminate the cold-air plenum beneath the floor and to incorporate appropriate supply-air diffusers (possibly ceiling-mounted ones).

3. Reheat capability should be provided year-round for AHS-301 (serving the Adjustments Branch in Building 3), so that zone thermostats in its service area are operational. (Concurrently, SA which is sufficiently cool to achieve room temperatures as low as 72°F should be provided by the AHU.) This likely will increase occupant satisfaction with thermal conditions. The services of a qualified mechanical contractor with engineering capability should be obtained, to review AHS-301 design features such as supply-air diffuser types (and their applicability to high ceilings) and velocities, supply-air distribution (flowrates) and its affect on "effective" outside-air delivery rates, thermostat locations, and the use of a fully unducted return system. If problems persist, further monitoring of CO_2 concentrations in the area during very warm or very cold weather might help determine whether increasing the minimum outside-air intake rate and/or making changes (e.g., diffuser types) to encourage better air mixing is indicated.

4. The review of the design features of AHS-301 will help determine if certain features (such as the supply-air diffuser types, applicability to high ceilings, and velocities; and, the use of a fully unducted return systems) shared by numerous other AHSs in the facility are appropriate. The many changes to that have been made in space utilization in the facility through the years, and the addition and/or movement of partitions and other barriers over time without corresponding HVAC-system changes, indicate that a review of factors such as supply-air flowrates,

"effective" outside-air delivery rates, and thermostat locations is likely due for many AHSs in this facility.

5. Ergonomic consultation should be obtained to determine the proper ergonomic furniture needed for prolonged personal computer use.

6. Smoking should be prohibited in the indoor, occupational environment, including this facility; currently, air contaminated with secondary cigarette smoke moves from at least one designated smoking area into adjacent spaces, and may be recirculated from there to other spaces by central air-handling systems. A smoking cessation program may be necessary to assist those employees who are current smokers. If this is not feasible, smoking should be restricted only to designated smoking rooms and lounges that are provided with properly designed, effective exhaust ventilation (since exposure to environmental tobacco smoke is one of the most important sources of indoor air quality problems, contributing both particulates and gaseous contaminants). The exhaust ventilation systems should discharge room air directly to the outside, an arrangement which eliminates the possibility of re-entrainment and recirculation of any secondary cigarette smoke. In addition, negative static pressure should be maintained in smoking lounges, relative to surrounding occupied areas. The exhaust-ventilation airflow rate must also be at least 60 cfm per person for smoking lounges, according to ASHRAE™ Standard 62–1989.[23] Air entering a smoking lounge to make up for that exhausted need not be outdoor air necessarily, but may be "transfer air" from surrounding spaces and/or supply air from a central air-handling unit. However, no return air should be recirculated from the smoking lounge to a central air-handling unit. A reputable mechanical firm with HVAC-engineering capability should be consulted to design such a system.

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Follow-up Survey, August 18 and 19, 1992

Table 1. Symptoms Experienced While At Work On The Day Of The Questionnaire Survey

Symptoms Reported	Building 2 47 workers	Building 3 127 Workers	All Respondents 174 workers
Dry, itching, or irritated eyes	60 %	51 %	53 %
Wheezing	9 %	11 %	10 %
Headache	51 %	48 %	49 %
Sore throat	34 %	24 %	27 %
Unusual tiredness, fatigue or drowsiness	57 %	62 %	61 %
Chest tightness	15 %	15 %	15 %
Stuffy or runny nose, or sinus congestion	36 %	46 %	44 %
Cough	32 %	22 %	25 %
Tired or strained eyes	70 %	66 %	67 %
Difficulty remembering things or concentrating	26 %	31 %	29 %
Dry throat	47 %	39 %	41 %
Dizziness or lightheadedness	30 %	25 %	26 %
Shortness of breath	19 %	15 %	16 %

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York
Follow-up Survey, August 18 and 19, 1992
Table 2. Symptoms Experienced At Work One or More Days Per Week During the Four Weeks Prior to the Survey

Symptoms Reported	Building 2 47 workers	Building 3 127 workers	All Respondents 174 workers
Dry, itching, or irritated eyes	57 %	57 %	57 %
Wheezing	13 %	16 %	15 %
Headache	51 %	59 %	57 %
Sore throat	36 %	23 %	26 %
Unusual tiredness, fatigue or drowsiness	66 %	76 %	73 %
Chest tightness	11 %	17 %	16 %
Stuffy or runny nose, or sinus congestion	45 %	56 %	53 %
Cough	36 %	24 %	27 %
Tired or strained eyes	66 %	76 %	74 %
Difficulty remembering things or concentrating	28 %	37 %	34 %
Dry throat	45 %	44 %	44 %
Dizziness or lightheadedness	34 %	36 %	36 %
Shortness of breath	13 %	24 %	21 %

HETA 91-0174
Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York
Follow-up Survey, August 18 and 19, 1992
Table 3. Symptoms Experienced While At Work One Or More Days Per Week
During The Four Weeks Prior to the Survey That Tended to be Less Severe When Away From Work

Symptoms Reported	Building 2 47 workers	Building 3 127 Workers	All Respondents 174 workers
Dry, itching, or irritated eyes	49 %	54 %	52 %
Wheezing	9 %	10 %	10 %
Headache	43 %	51 %	49 %
Sore throat	28 %	18 %	21 %
Unusual tiredness, fatigue or drowsiness	49 %	57 %	55 %
Chest tightness	9 %	13 %	12 %
Stuffy or runny nose, or sinus congestion	23 %	42 %	37 %
Cough	23 %	18 %	20 %
Tired or strained eyes	51 %	65 %	61 %
Difficulty remembering things or concentrating	13 %	26 %	22 %
Dry throat	38 %	39 %	39 %
Dizziness or lightheadedness	26 %	32 %	30 %
Shortness of breath	9 %	19 %	16 %

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Follow-up Survey, August 18 and 19, 1992

Table 4. Number Of Employees Reporting Symptoms That Occurred At Work One Or More Days Per Week During the Four Weeks Prior to the Survey That Tended to be Less Severe When Away From Work

Number Of "Work Related" Symptoms Reported	Building 2 47 workers	Building 3 127 workers	All Respondents 174 workers
No Symptoms	13	22	35
One Symptom	5	12	17
Two Symptoms	4	12	16
Three Symptoms	3	19	22
Four Symptoms	7	19	26
Five Symptoms	9	13	22
Six Symptoms	5	20	25
Seven Symptoms	1	10	11

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Follow-up Survey, August 18 and 19, 1992

Table 5. Description Of Workplace Conditions On Day of Survey

Conditions Reported	Building 2 47 workers	Building 3 127 workers	All Respondents 174 workers
Too much air movement	23 %	9 %	13 %
Too little air movement	55 %	86 %	78 %
Temperature too hot	26 %	77 %	63 %
Temperature too cold	72 %	27 %	39 %
Air too humid	23 %	30 %	28 %
Air too dry	49 %	54 %	53 %
Chemical odors (e.g., paint, cleaning fluids, etc.)	23 %	13 %	16 %
Other unpleasant odors (e.g., body odor, food odor, perfume)	38 %	38 %	38 %

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Follow-up Survey, August 18 and 19, 1992

Table 6. Description Of Workplace Conditions During the Four Weeks Prior to the Survey

Conditions "Frequently" Experienced	Building 2 47 workers	Building 3 127 workers	All Respondents 174 workers
Too much air movement	32 %	10 %	16 %
Too little air movement	57 %	84 %	77 %
Temperature too hot	23 %	61 %	51 %
Temperature too cold	77 %	42 %	51 %
Air too humid	30 %	24 %	25 %
Air too dry	57 %	59 %	58 %
Chemical odors (e.g., paint, cleaning fluids, etc.)	26 %	17 %	19 %
Other unpleasant odors (e.g., body odor, food odor, perfume)	40 %	41 %	41 %

HETA 91-0174
Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Initial Survey, March 25, 1992

Table 7. Measured Air Temperatures, Relative Humidities, and Carbon Dioxide (CO_2) Concentrations

Location	Time (military)	CO_2 Concentration (ppm)	Temperature (°F)	Relative Humidity (% Saturation)	Dew Point (°F)
Bldg. 4, Facilities	0830	475	74.0	18 %†#	28†#
Management		550*	73.8**	15 %†#	26†#
Branch	1350	600	72.4	24.5 %#	35 #
		---	71.9**	23 %†#	33†#
Bldg. 3,	0920	775	72.8	21.4%†#	32†#
Adjustments Branch	0925	---	72.6	21.8%†#	32†#
	1437	775	74.5	25.6% #	37 #
	1439	---	74.5	26.1% #	37 #
Bldg. 3, P.R.O.	0940	625	71.6	20.1%†#	29†#
	1444	600	74.6	24.6% #	36 #
Bldg. 3, Collection	0950	725	70.8	22.0%†#	31†#
Branch	0958	750	72.1	21.6%†#	32†#
	1451	675	73.2	26.1% #	36 #
Bldg. 2,	1010	625	71.9	22.7%†#	33†#
Timekeeping	1458	575	72.9	28.2% #	39 #
Bldg. 2, TeleTIN	1020	625 (650*)	72.8	22.4%†#	33†#
	1503	550	73.5	28.1% #	39 #

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Initial Survey, March 25, 1992

Table 7 (Continued). Measured Air Temperatures, Relative Humidities, and Carbon Dioxide (CO_2) Concentrations

Location	Time (military)	CO_2 Concentration (ppm)	Temperature (°F)	Relative Humidity (% Saturation)	Dew Point (°F)
Bldg. 2, Computer Room Support Area	1510	625	77.9‡	31.0%	45
Outdoor Ambient	1050	375	50.7	40 %	28
		---	50**	38 %	27
	1519	350	45.4	65.5%	35

* Reported CO_2 concentration measured with colorimetric Dräger 0.01%/a CO_2 detector tubes. All other (unmarked) concentrations measured with GasTech RI411A infrared CO_2 meter.

** Reported air temperature and relative humidity measured with an automatic psychrometer. All others (unmarked) measured with a Vaisala HM34 meter.

† Humidity below the minimum specified (which is an absolute humidity corresponding to a dew point of 36°F) in the ASHRAE thermal-comfort criteria, ANSI/ASHRAE Standard 55-1992.

Relative humidity below the recommended minimum of 30% specified in ASHRAE™ Standard 62-1989.

‡ Temperature above the winter range specified in the ASHRAE thermal-comfort criteria, ANSI/ASHRAE Standard 55-1992.

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Follow-up Survey, August 18, 1992

Table 8. Measured Air Temperatures, Relative Humidities, Velocities, and Carbon Dioxide (CO_2) Concentrations. Area Served by AHS-204, Building 2, RPS and Data Conversion

Location (No.) (Building 2)	Time (military)	CO_2 Concentration (ppm)	Near Floor		4 ft above Floor		Velocity (fpm)		
			Temperature (°F)	Relative Humidity (% Saturation)	Temperature (°F)	Relative Humidity (% Saturation)	Near Floor	4-ft High	7-ft High
(1) Section Chief	0724	500	66	61%	70	65%	7	12	15
Office, near	0836	475	--	--	--	--	--	--	--
pillar 2-B-2	1027	500	69	63%	71	59%	--	--	--
	1125	575	--	--	--	--	--	--	--
	1251	500	69	61%	71	60%	13	6	26
	1602	475	--	--	--	--	--	--	--
(2) Between	0735	525	69	66%	70	60%	20	25	26
pillars 2-B-3 and	0837	425	--	--	--	--	--	--	--
2-B-4	1030	550	70	66%	71	62%	--	--	--
	1134	500	--	--	--	--	--	--	--
	1256	500	70	65%	71	61%	7	19	14
	1604	425	--	--	--	--	--	--	--
(3) Near pillars	0742	525	70	62%	71	60%	13	12	21
2-B-4, near floor	0840	550	--	--	--	--	--	--	--
vents	1032	525	69	67%	71	59%	--	--	--
	1138	500	--	--	--	--	--	--	--
	1302	525	70	60%	71	59%	25	24	17
	1605	450	--	--	--	--	--	--	--

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Follow-up Survey, August 18, 1992

Table 8 (Continued). Measured Air Temperatures, Relative Humidities, Velocities, and Carbon Dioxide (CO_2) Concentrations. Area Served by AHS-204, Building 2, RPS and Data Conversion

Location (No.) (Building 2)	Time (military)	CO_2 Concentration (ppm)	Near Floor		4 ft above Floor		Velocity (fpm)		
			Temperature (°F)	Relative Humidity (% Saturation)	Temperature (°F)	Relative Humidity (% Saturation)	Near Floor	4-ft High	7-ft High
(4) Near pillar 2-B-4, near partition	0752	550	70	61%	72	59%	17	10	14
	0841	475	--	--	--	--	--	--	--
	1034	525	70	62%	71	60%	--	--	--
	1137	525	--	--	--	--	--	--	--
	1307	500	70	61%	71	59%	11	11	12
	1607	450	--	--	--	--	--	--	--
(5) Near pillars 2-B-7 and 2-B-8	0808	475	70	57%	72	55%	--	--	--
	0850	450	--	--	--	--	19	28	25
	1039	475	70	56%	72	56%	--	--	--
	1144	475	--	--	--	--	--	--	--
	1315	500	70	56%	72	55%	34	16	17
	1610	450	--	--	--	--	--	--	--
(6) South of pillar 2-B-7	0810	525	70	64%	72	59%	--	--	--
	0842	475	--	--	--	--	9	19	20
	1041	525	71	63%	72	59%	--	--	--
	1149	475	--	--	--	--	--	--	--
	1325	500	71	61%	74	58%	8	21	8
	1612	525	--	--	--	--	--	--	--

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Follow-up Survey, August 18, 1992

Table 8 (Continued). Measured Air Temperatures, Relative Humidities, Velocities, and Carbon Dioxide (CO_2) Concentrations. Area Served by AHS-204, Building 2, RPS and Data Conversion

Location (No.) (Building 2)	Time (military)	CO_2 Concentration (ppm)	Near Floor		4 ft above Floor		Velocity (fpm)		
			Temperature (°F)	Relative Humidity (% Saturation)	Temperature (°F)	Relative Humidity (% Saturation)	Near Floor	4-ft High	7-ft High
(7) South of pillar 2-B-6	0813	450	70	66%	73	60%	--	--	--
	0857	450	--	--	--	--	31	12	11
	1043	475	70	67%	72	61%	--	--	--
	1151	450	--	--	--	--	--	--	--
	1325	425	70	64%	72	61%	19	20	21
	1613	500	--	--	--	--	--	--	--
(8) North of pillars 2-B-5 and 2-B-6	0816	450	70	57%	73	54%	--	--	--
	0903	425	--	--	--	--	31	22	22
	1048	550	70	56%	72	55%	--	--	--
	1153	425	--	--	--	--	--	--	--
	1330	425	71	57%	72	55%	20	22	18
	1615	475	--	--	--	--	--	--	--
(9) North of pillar 2-B-5	0908	475	69	58%	72	56%	15	11	13
	1052	475	69	58%	72	56%	--	--	--
	1155	475	--	--	--	--	--	--	--
	1337	475	69	56%	72	55%	21	20	17
	1618	475	--	--	--	--	--	--	--
Outside Air	1510	325	NA	NA	76	70%	NA	NA	NA

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Holtsville, New York

Follow-up Survey, August 19, 1992

Table 9. Measured Air Temperatures, Relative Humidities, Velocities, and Carbon Dioxide (CO_2) Concentrations. Area Served by AHS-301, Building 3, Adjustments Branch

Location (No.) (Building 3)	Time (military)	CO_2 Concentration (ppm)	Near Floor		4 ft above Floor		Velocity (fpm)		
			Temperature (°F)	Relative Humidity (% Saturation)	Temperature (°F)	Relative Humidity (% Saturation)	Near Floor	4-ft High	7-ft High
(1) Branch	0725	500	72	62%	72	60%	--	--	--
Office, near	0836	625	--	--	--	--	19	14	9
pillar 3-A-8	1118	875	73	57%	73	57%	--	--	--
	1246	675	--	--	--	--	29	14	14
	1603	625	--	--	--	--	--	--	--
(2) Between	0729	600	73	58%	73	58%	--	--	--
pillars 3-B-8 and	0840	750	--	--	--	--	--	--	--
3-B-7	1122	775	73	55%	73	55%	--	--	--
	1253	750	--	--	--	--	12	20	15
	1434	775	74	53%	73	53%	--	--	--
	1604	675	--	--	--	--	--	--	--
(3) At pillar	0732	600	74	58%	74	56%	--	--	--
3-B-9	0846	750	--	--	--	--	--	--	--
	1124	900	74	53%	74	54%	--	--	--
	1256	725	--	--	--	--	28	24	17
	1437	800	75	53%	75	53%	--	--	--
	1606	750	--	--	--	--	--	--	--

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Follow-up Survey, August 19, 1992

Table 9 (Continued). Measured Air Temperatures, Relative Humidities, Velocities, and Carbon Dioxide (CO_2) Concentrations. Area Served by AHS-301, Building 3, Adjustments Branch

Location (No.) (Building 3)	Time (military)	CO_2 Concentration (ppm)	Near Floor		4 ft above Floor		Velocity (fpm)		
			Temperature (°F)	Relative Humidity (% Saturation)	Temperature (°F)	Relative Humidity (% Saturation)	Near Floor	4-ft High	7-ft High
(4) North of pillar 3-B-9	0733	650	74	56%	75	57%	--	--	--
	0849	750	--	--	--	--	28	30	15
	1126	800	75	54%	75	54%	--	--	--
	1301	700	--	--	--	--	--	--	--
	1439	775	76	52%	76	52%	--	--	--
	1607	725	--	--	--	--	--	--	--
(5) Near pillar 3-A-11	0737	600	75	57%	75	57%	--	--	--
	0853	750	--	--	--	--	39	41	--
	1130	800	76	54%	76	54%	--	--	--
	1311	675	--	--	--	--	--	--	--
	1444	725	76	52%	76	52%	42	55	50
	1610	750	--	--	--	--	--	--	--
(6) Near pillar 3-B-11	0739	650	75	57%	75	57%	--	--	--
	0902	750	--	--	--	--	16	20	14
	1133	825	75	54%	75	54%	--	--	--
	1316	750	--	--	--	--	--	--	--
	1450	700	75	51%	75	51%	36	32	20
	1610	725	--	--	--	--	--	--	--

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Follow-up Survey, August 19, 1992

Table 9 (Continued). Measured Air Temperatures, Relative Humidities, Velocities, and Carbon Dioxide (CO_2) Concentrations. Area Served by AHS-301, Building 3, Adjustments Branch

Location (No.) (Building 3)	Time (military)	CO_2 Concentration (ppm)	Near Floor		4 ft above Floor		Velocity (fpm)		
			Temperature (°F)	Relative Humidity (% Saturation)	Temperature (°F)	Relative Humidity (% Saturation)	Near Floor	4-ft High	7-ft High
(7) Near pillar 3-B-12	0742	675	75	58%	75	57%	--	--	--
	0906	775	--	--	--	--	--	--	--
	1135	800	75	55%	75	56%	--	--	--
	1318	675	--	--	--	--	--	--	--
	1458	700	75	53%	75	53%	29	26	21
	1612	725	--	--	--	--	--	--	--
(8) Near pillar 3-A-12	0744	650	75	58%	75	57%	--	--	--
	0914	750	--	--	--	--	--	--	--
	1140	800	75	55%	75	55%	--	--	--
	1319	650	--	--	--	--	--	--	--
	1504	700	74	53%	76	53%	27	34	29
	1613	725	--	--	--	--	--	--	--
(9) North of pillar 3-B-13	0754	700	74	59%	74	58%	--	--	--
	0919	725	--	--	--	--	--	--	--
	1144	775	75	57%	75	56%	--	--	--
	1321	650	--	--	--	--	--	--	--
	1510	675	75	55%	75	54%	17	15	20
	1618	700	--	--	--	--	--	--	--

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Follow-up Survey, August 19, 1992

Table 9 (Continued). Measured Air Temperatures, Relative Humidities, Velocities, and Carbon Dioxide (CO_2) Concentrations. Area Served by AHS-301, Building 3, Adjustments Branch

Location (No.) (Building 3)	Time (military)	CO_2 Concentration (ppm)	Near Floor		4 ft above Floor		Velocity (fpm)		
			Temperature (°F)	Relative Humidity (% Saturation)	Temperature (°F)	Relative Humidity (% Saturation)	Near Floor	4-ft High	7-ft High
(10) Near pillar	0747	725	74	59%	74	58%	--	--	--
3-B-13	0918	775	--	--	--	--	--	--	--
	1147	775	74	56%	75	56%	--	--	--
	1323	650	--	--	--	--	--	--	--
	1514	675	75	54%	75	54%	24	50	19
	1619	700	--	--	--	--	--	--	--
Outside Air	1510	375	NA	NA	80	61%	NA	NA	NA

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Follow-up Survey, August 18, 1992

Table 10. Description of Workplace Conditions on Day of Survey
(Responses Shown for Workers near Each Monitoring Location)
Building 2, RPS and Data Conversion

Monitoring Location (Building 2)	Questionnaire Response of "Yes, on the Day of Survey"					
	"Too Much Air Movement"	"Too Little Air Movement"	"Too Hot"	"Too Cold"	"Too Humid"	"Too Dry"
1	33% (2/6)	67% (4/6)	17% (1/6)	33% (2/6)	0% (0/6)	50% (3/6)
2	25% (1/4)	50% (2/4)	25% (1/4)	100% (4/4)	0% (0/1)	50% (2/4)
3	0% (0/5)	20% (1/5)	40% (2/5)	80% (4/5)	0% (0/5)	20% (1/5)
4	0% (0/5)	40% (2/5)	0% (0/5)	100% (5/5)	40% (2/5)	60% (3/5)
5	42% (5/12)	42% (5/12)	0% (0/12)	83% (10/12)	25% (3/12)	25% (3/12)
6	0% (0/5)	60% (3/5)	20% (1/5)	60% (3/5)	40% (2/5)	60% (3/5)
7	0% (0/1)	100% (1/1)	0% (0/1)	100% (1/1)	0% (0/1)	0% (0/1)
8	33% (1/3)	100% (3/3)	100% (3/3)	67% (2/3)	67% (2/3)	100% (3/3)
9	33% (2/6)	83% (5/6)	67% (4/6)	50% (3/6)	33% (2/6)	83% (5/6)
Entire Area	23% (11/47)	55% (26/47)	26% (12/47)	72% (34/47)	23% (11/47)	49% (23/47)

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Brookhaven Internal Revenue Service Center, U.S. Department of the Treasury, Internal Revenue Service
Holtsville, New York

Follow-up Survey, August 19, 1992
Table 11. Description of Workplace Conditions on Day of Survey
(Responses Shown for Workers near Each Monitoring Location)
Building 3, Adjustments Branch

Monitoring Location (Building 3)	Questionnaire Response of "Yes, on the Day of Survey"					
	"Too Much Air Movement"	"Too Little Air Movement"	"Too Hot"	"Too Cold"	"Too Humid"	"Too Dry"
1*	(NR)	(NR)	(NR)	(NR)	(NR)	(NR)
2	0% (0/3)	67% (2/3)	100% (3/3)	0% (0/3)	67% (2/3)	67% (2/3)
3	9% (2/22)	77% (17/22)	64% (14/22)	27% (6/22)	36% (8/22)	41% (9/22)
4	6% (1/18)	94% (17/18)	83% (15/18)	22% (4/18)	33% (6/18)	33% (6/18)
5	17% (2/12)	100% (12/12)	100% (12/12)	8% (1/12)	67% (8/12)	50% (6/12)
6	16% (3/19)	74% (14/19)	68% (13/19)	26% (5/19)	16% (3/19)	53% (10/19)
7	10% (2/20)	95% (19/20)	80% (16/20)	35% (7/20)	25% (5/20)	80% (16/20)
8	0% (0/13)	92% (12/13)	85% (11/13)	8% (1/13)	31% (4/13)	46% (6/13)
9	0% (0/8)	100% (8/8)	75% (6/8)	38% (3/8)	0% (0/8)	75% (6/8)
10	8% (1/12)	67% (8/12)	67% (8/12)	58% (7/12)	17% (2/12)	67% (8/12)
Entire Area	9% (11/127)	86% (109/127)	77% (98/127)	27% (34/127)	30% (38/127)	54% (69/127)

NR = No respondents
* = Only one employee worked at this location. This employee did not respond.

HEALTH HAZARD EVALUATION REPORT

HETA 91-0174-2468
U.S. DEPARTMENT OF THE TREASURY, INTERNAL REVENUE SERVICE BROOKHAVEN SERVICE CENTER HOLTSVILLE, NEW YORK