SONIC ANEMOMETER MEASUREMENT WITHIN A ROOM

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Results are reported on the use of a 5 cm path-length sonic anemometer for the measurement of turbulent fluctuations in two small rooms. Doors and windows were closed with the forced air circulation system turned on. Measurements were taken at three heights (floor, middle and ceiling). Data were recorded for 10-minute periods at 10 Hz at each sampling location, defined as a run. Except within the corners or above the vents, the flow was nearly isotropic, with speeds on the order of 15 cm s^{-1} and a standard deviation of 6.7 cm s^{-1}. Approximately, 10 to 20% of the measured component velocities were below the threshold of the instrument's uncertainty. The speed threshold of 2 to 5 cm s^{-1} will limit the usefulness of this instrument.

INTRODUCTION

Characterizations of aerosol formation and deposition within rooms often involve measurement or characterization of the turbulent velocity fluctuations within the rooms (1,2). In anticipation of future research regarding indoor aerosols, we investigated the feasibility of using a small (5 cm path-length) sonic anemometer for measurement and characterization of velocity fluctuations within rooms. The sonic anemometer employed was the Kaijo Denki WAT-300. The instrument has been used with success in wind tunnel investigations of sonic anemometer response (3) and in several field studies.

MATERIALS & METHODS

Two rooms within a mobile home trailer were used in the study, see figure 1. The trailer had been converted to office space in the 1970's and had been vacant in recent years. The smaller room was approximately 2.7 m by 3.0 m, with a 2.4 m ceiling. The larger room was approximately 2.8 m by 6.1 m, with a 2.4 m ceiling. All doors and windows were closed with the forced air circulation system turned on. The vents were located in the floor and the air was blown vertically toward the ceiling. The small room had one vent centrally located along one wall, while the larger room had two vents located along the 6.1 m long wall.

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1 On Assignment From National Oceanic Atmospheric Administration

Sonic anemometer measurements were taken at several locations at each of three heights in the room (floor, middle and ceiling). For these preliminary tests, there was only one run per location. Direct measurements of air exchange between rooms and with the outdoors were not made, but trials were conducted during a period with overcast skies and relatively steady winds. Therefore, even though the details of the flow fields may have differed between runs, we anticipate similar turbulence structure within the rooms in general.

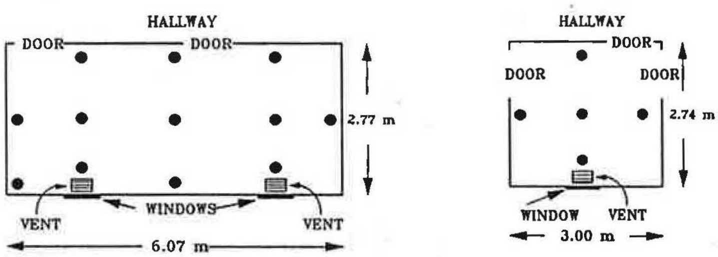

Figure 1. Plan view of trailer rooms, showing location of vents, windows and doors. Black dots show sampling locations.

Data were recorded on a personal computer for 10-minute periods (defined as a run) at 10 Hz at each of the sampling locations. The instrument's most sensitive ranges were selected for use in these experiments (± 1 m s^{-1} for the vertical velocity and ±2.5 m s^{-1} for the horizontal velocity). With these settings, the limiting factor is the uncertainty of the measurements (2% of the range selected, or 2 cm s^{-1} in the vertical and 5 cm s^{-1} in the horizontal).

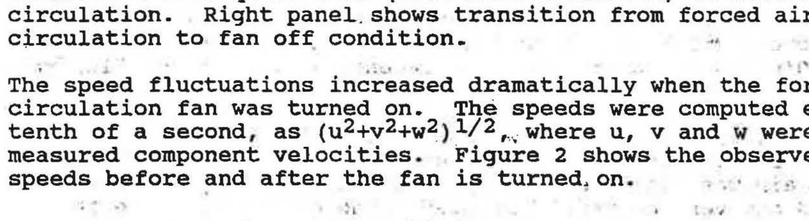

Figure 2. Speed fluctuations in smaller room. Left panel shows transition from quiet room (circulation fan off) to forced air circulation. Right panel shows transition from forced air circulation to fan off condition.

The speed fluctuations increased dramatically when the forced air circulation fan was turned on. The speeds were computed each tenth of a second, as $(u^2+v^2+w^2)^{1/2}$, where u, v and w were the measured component velocities. Figure 2 shows the observed speeds before and after the fan is turned on.

RESULTS & DISCUSSION

In general, the turbulence levels, as defined by the standard deviations of the horizontal, u and v, and vertical, w, velocity components, were largest at the ceiling and along the walls adjacent to the vents. The standard deviations of the component velocity fluctuations, for the smaller room, were on the order of 6 cm s^{-1} within the central core of the room, and on the order of 8 to 14 cm s^{-1} along the wall with the vent. Mean speeds were on the order of 14 cm s^{-1} in the central region, and on the order of 24 cm s^{-1} along the wall with the vent. The standard deviations of the component velocity fluctuations, for the larger room, were on the order of 7 to 11 cm s^{-1} in the central core, and on the order of 14 to 17 cm s^{-1} along the wall with the vents. Mean speeds in the central core was on the order of 19 cm s^{-1}, as compared to 40 cm s^{-1} along the wall with the vents.

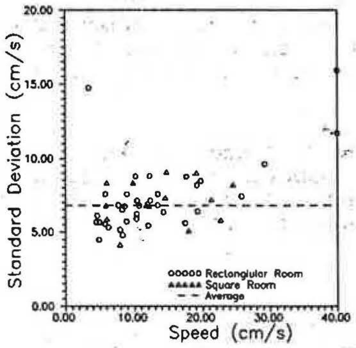

Figure 3. Comparison of average standard deviation of velocity components versus speed at each sampling location. The average of 6.7 cm s^{-1} was computed ignoring the three sampling locations where the flow was forced to turn, resulting in very large standards deviations.

Based on a comparison of the observed variances of the velocity components, it was concluded that within the tolerance of these measurements, the variance of the velocity components was isotropic. Figure 3 was constructed to investigate whether the variance in the velocity components might be related to the mean speed, and or location within the room. The figure compares the standard deviation of the velocity components, averaged at each location over the three components, versus the computed average speed. The largest variances are observed at the ceiling in the rectangular room, in the corner, between the vents and in the center of the room. These are easily explained as in these locations the flow from the vents has been strongly disrupted by the barrier presented by the ceiling. Disregarding these values, there is no significant correlation between the variance of the velocity components and the average speed, nor does there appear to be a location dependence.

The limiting factor in the use of this instrument is the uncertainty of the measurements. To further assess this, two runs were investigated in more detail, one run for each room in the center sampling location. For each velocity component, the percentage of measurements below the instrument's uncertainty was determined. For the square room, 10% and 50% of the horizontal, u and v, velocity measurements were less than ±5 cm s^{-1}, and 19% of the vertical, w, velocity measurements were less than ±2 cm s^{-1}. For the rectangular room, 9% and 23% of the horizontal velocity measurements were less than ±5 cm s^{-1}, and 6% of the vertical velocity measurements were less than ±2 cm s^{-1}.

CONCLUSIONS & RECOMMENDATIONS

Given the frequent occurrence of very small speeds, even in these experiments where the circulation is constantly forced, the overall accuracy of the instrument restricts the situations in which useful measurements are possible. Where the flow is on the order of 20 cm s^{-1} or more, such as in the vicinity of vents, the instrument is capable of yielding useful measurements.

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DISCLAIMER

Mention of trade names of commercial products does not constitute endorsement or recommendation for use. Although the research described in this article has been supported by the United States Environmental Protection Agency, it has not been formally released by the U.S. Environmental Protection Agency and should not at this stage be construed to represent Agency policy. It is currently undergoing internal review and clearance for technical merit and policy implications.

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