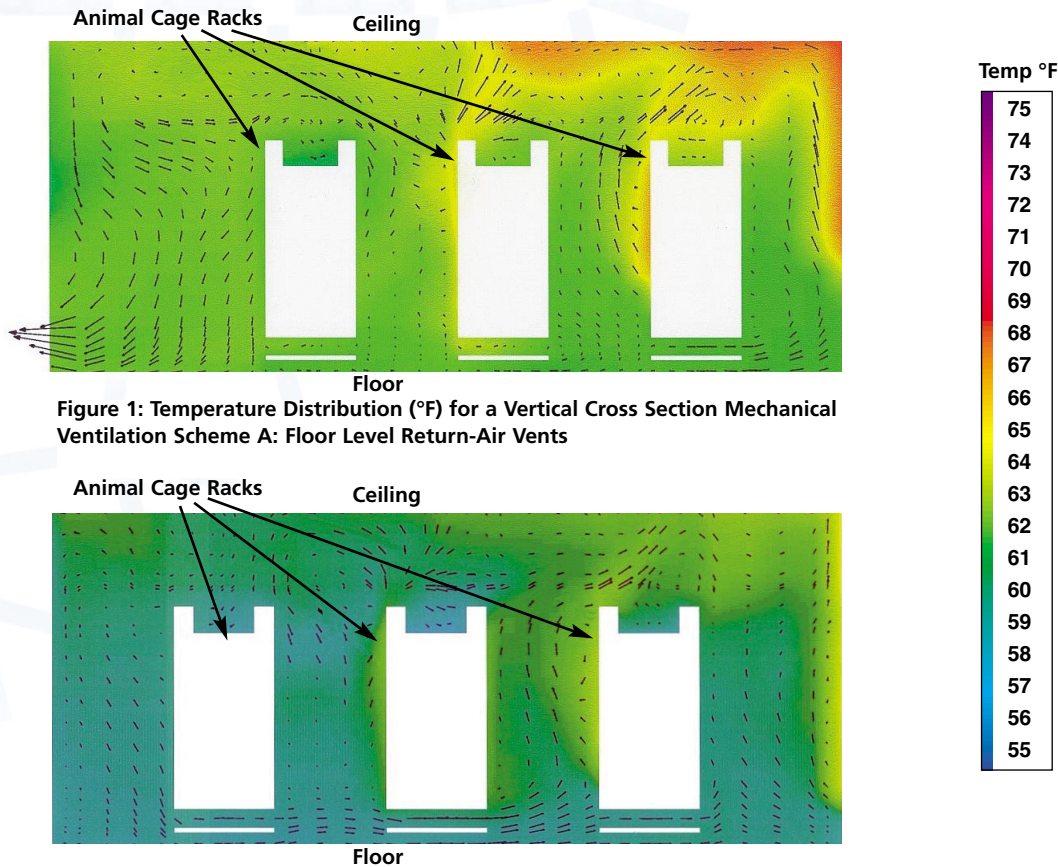


AIRFLOW ANALYSIS OF A MOUSE HOLDING ROOM

By Ray Sinclair, Principal and Mark Vanderheyden, Principal



Early in the design process, RWDI assisted the mechanical design engineering team in determining the optimum configuration of the mechanical system for an animal holding room. Computer simulations of the airflow patterns in the room were performed using Computational Fluid Dynamics (CFD) techniques. The CFD model accounts for the room geometry which was 10 ft. x 19 ft. and the obstructions in the room which were six racks of animals cages with 98 cages in each rack. Also included were the proposed ventilation system, the cage systems, leakage and heat loads from the fans, lighting, and laboratory animals. Each rack had a supply fan, which drew air from the room and supplied it to each of the cages, and an exhaust fan, which vented the air into the room at the top of the rack through a plenum common to each rack.

Figures 1 and 2 are vertical cross section views showing the temperature distributions in the animal holding room for two different mechanical ventilation schemes. The white silhouettes are the locations of the racks of animal cages. The bottom row of each rack was modelled without animal cages. There is also a gap between the bottom of the rack and the room floor. The arrows shown on the figures represent the flow direction and their length indicates the relative air speed in the plan of the cross section. The color range for these temperature plots is from dark blue, which is 55°F, to magenta, which is 75°F.

For the case shown in Figure 1, the mechanical system consisted of two 4-way diffusers located on the ceiling with two return grilles located on the end walls, 8 inches above the floor in diagonally opposite corners of the room. For the second case, shown in Figure 2, the system had similar ceiling diffusers, but the return grilles were located in the ceiling at the four corners of the room.

Examining Figure 1, it is evident that the temperature distribution is not uniform. The upper right corner of the

plot shows a region where the warm air exhausted from the racks is trapped near the ceiling. Figure 2 illustrates the advantage of relocating the return grilles to the ceiling. The overall uniformity of the temperature distribution was improved and the average room temperature was lowered as well.

Further analysis of the other mechanical system design options, not shown here, resulted in recommendations regarding the optimal number and location of the return grilles. These tests indicated that two ceiling returns, located in the corners where the fans from the animal cage racks exhausted, performed equivalently to four ceiling return grilles. Our client indicated that this was expected to yield a savings in terms of the amount of stainless steel ducting required. Other suggestions were made by the RWDI team with respect to the orientation of the exhaust jets from the racks.

The study demonstrated that the choice of ventilation system is highly dependent upon the type, location and density of cages and other equipment within the space.

AIRFLOW ANALYSIS OF A SWINE HOLDING ROOM

By Ray Sinclair, Principal and Mark Vanderheyden, Principal

An animal room was divided into 26 open swine pens, arranged in two rows with a central aisle. The pens were built on a raised floor to facilitate cleaning. The two configurations consisted of two supply diffusers equally spaced above the central aisle and two returns on the end walls. In one case the returns were just above the floor and in the other they were at ceiling height. All lighting and animal heat loads were included in the CFD model.

Figures 1 and 2 demonstrate the flow differences between the high and low returns respectively. The low return case results in considerably higher speeds below the pen floors. This translates into lower temperatures below the pens and higher temperatures higher in the pen, as shown by comparison of figures 3 and 4. This result indicates that the high return in this case is superior to the low return, since it reduces the short circuiting of supply air, providing more uniform temperatures and ventilation. It also reduces the speed of air over the manure catchment area below the pens. This could reduce the possibility of cross-contamination of animals via the manure.

Once again, the results illustrate the need to provide specific ventilation designs for specific holding room situations.

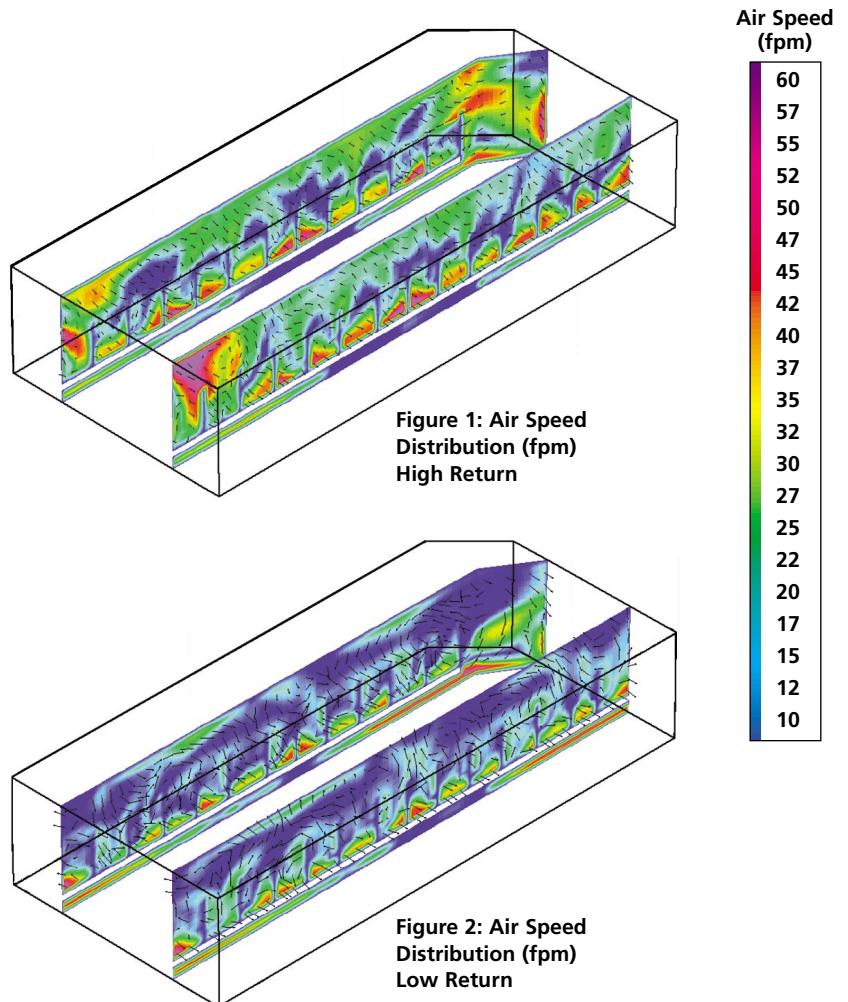


Figure 1: Air Speed Distribution (fpm) High Return

Figure 2: Air Speed Distribution (fpm) Low Return

Temp °F

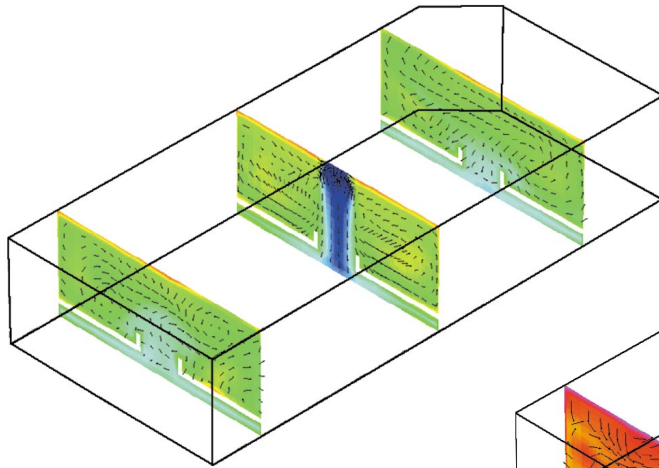
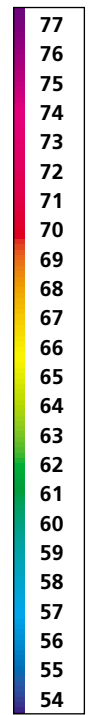


Figure 3: Temperature Distribution (°F) High Return

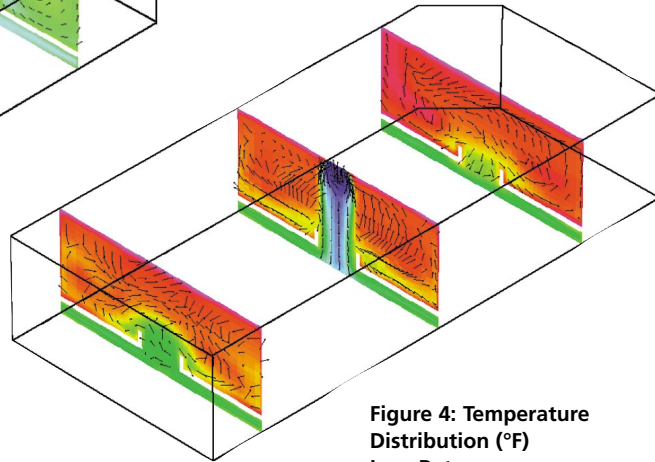


Figure 4: Temperature Distribution (°F) Low Return

AIRFLOW ANALYSIS OF A LABORATORY SPACE

By Glenn Schuyler, Principal

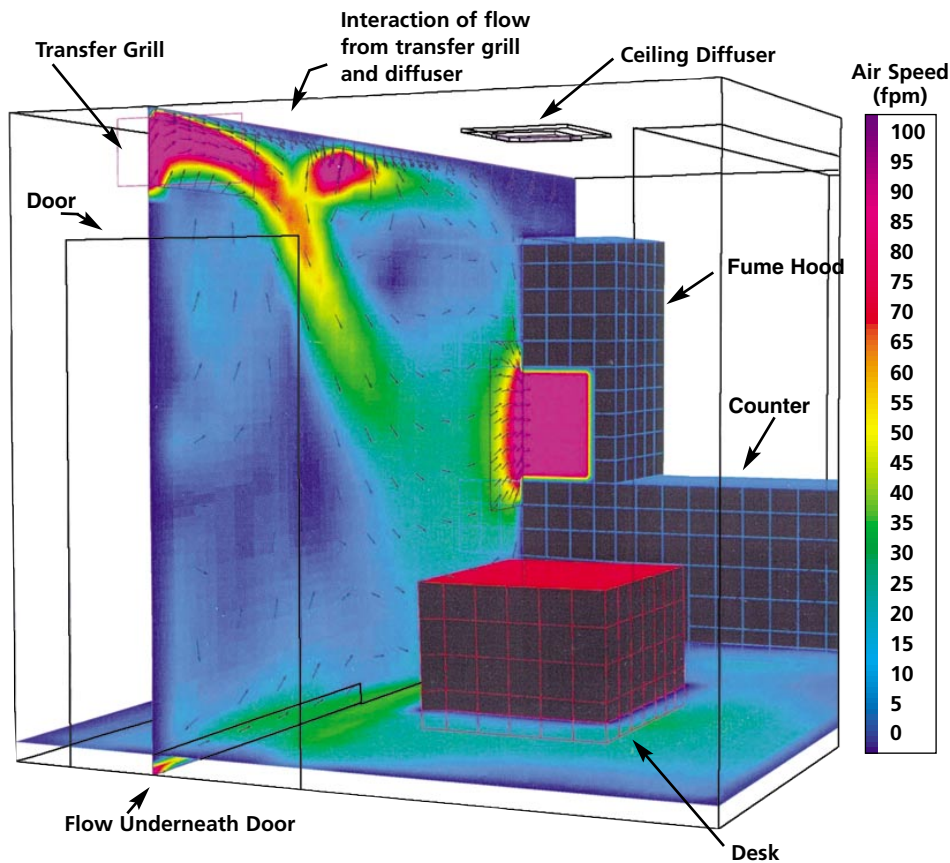


Figure 1: Air Velocities (FPM) Over Two Planes

RWDI validated a CFD model against velocities measured at over 400 locations within a laboratory. In addition, RWDI developed a method of assessing the effect of laboratory ventilation on the performance of laboratory fume hoods. In performing these tasks, certain room configurations whose negative effect on fume hood performance is well known in the industry were identified as negative using the CFD model and the fume hood performance assessment criterion. This demonstration lends considerable confidence to the use of CFD in predicting laboratory ventilation performance.

Figure 1 illustrates the room geometry and some of the flow characteristics within the room. Air is supplied via the square diffuser in the center of the room, the transfer grille over the door and the crack beneath the door. Air is exhausted via the fume hood in the corner of the room. Note the interaction of the diffuser jet and the transfer grille jet and their impact on the fume hood.

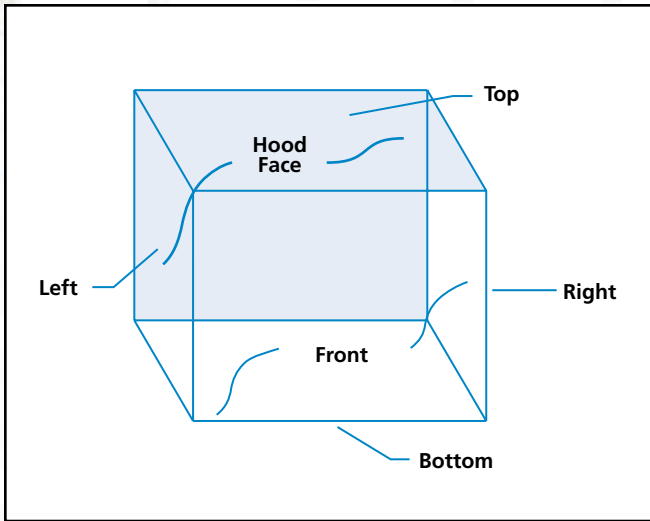


Figure 2: Imaginary Assessment Surface Attached to Hood Face

Figure 2 illustrates the fume hood assessment method. An imaginary surface equal to the fume hood face and located one foot away from the hood is joined to the hood on all four sides by smaller surfaces to the perimeter of the hood face. The assessment method first predicts the speed of air approaching the hood perpendicular to these surfaces for an ideal hood. This information was derived from work by DallaValle¹.

Next the predicted speed of air for the actual case is compared to the perfect case. A difference of greater than 50% of the face velocity of the hood is considered sufficient to disrupt the performance of the hood.

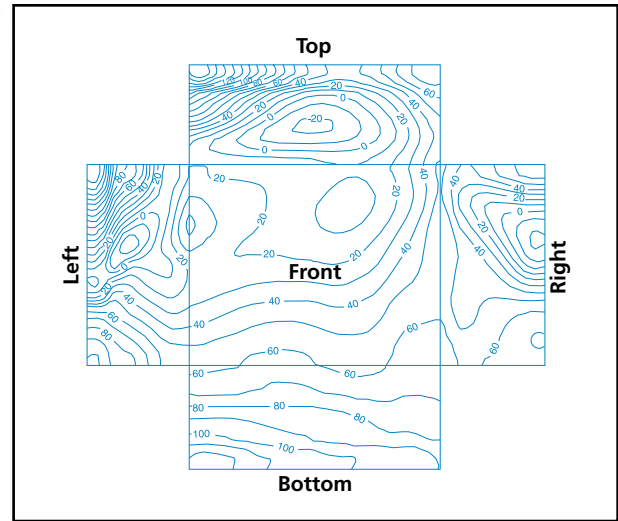


Figure 3: Velocity Difference (%)

Figure 3 is a contour plot of the velocity difference (%) for a case where air from the supply diffuser is allowed to strike the hood at the upper left corner. The flow differences are well above 50% of the face velocity, indicating hood failure. This result is consistent with the experience of laboratory designers.

The validation of actual predicted speeds using CFD and the validation of the fume hood assessment method allows us to use this method in cases where the interaction between ventilation air and the hood is not so obvious.

¹DallaValle, J.M., Exhaust Hoods, (2nd Edition), Industrial Press, New York, ©1952

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