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COMPUTATIONAL MODELING AND ANALYSIS OF A FLOW IN A STORAGE ROOM

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ABSTRACT

When a radioactive material gas is accidentally released with a room, the present of the hazardous gas will directly affect the people safety inside. In this study, the flow field and gas dispersion in a ventilated tritium storage room at Los Alamos National Laboratory was simulated using CFX-5.5, a commercially available CFD package using a finite volume methodology. CFD models provide a simultaneously numerical solution of continuity, Navier-Stokes, and energy equations for a flow field geometry with specified boundary conditions. CFX-5 uses a coupled solver, which solves the hydrodynamic equations (for u, v, w, p) as a single system. This reduces the number of iterations required for convergence to a steady state, and to a transient analysis solution for each time step in time-dependant gas dispersion as well.

A 3-D parametric model of the room was created in Unigraphics (UG 16). Details of the room are considered such as lights, wiring conduit, monitors and racks in the model. The ventilation system is modeled since the inlet and outlet ducts are exposed inside the room. A parasolid was exported from UG and imported in an advanced meshing tool of the CFX-5.5 pre-processor, called CFX-Build. An unstructured 3-D mesh containing over 2.0 million tetrahedral volumes was created using the parasolid as the baseline geometry of the room. Boundary conditions were directly applied according to the flow measurements taken in the room. Inlets were modeled as constant velocity inlet at angle of 25 degrees with respect to the ceiling and one outlet as constant velocity as well. Other source of air in the room is the gap under the door that allows air to flow in. The room is kept at negative pressure related to outside of one standard atmosphere with withdrawing more air out of the room than what the ventilation supplies. The air in the room was treated as incompressible and adiabatic flow. The three-dimensional, steady state, fluid field was computed using the κ-ε two-equation turbulence model. The gas was

simulated assuming dilute, mono-disperse, and neutrally buoyant particles. The steady state CFD solution was used as input in solving dispersion patterns of the spread of released gas in the room. Transient calculations of the gas dispersion by advection, turbulent diffusion, and molecular diffusion over a five-minute period were performed and gas concentration versus time was recorded at six potential sampling locations.

The results of steady state show a complex, ventilation-induced flow field with vortices, velocity gradient, and possible stagnant air pocket or some quiet zones. This paper explains also the time-dependent gas dispersion results. These results can be used to improve the design of the ventilation system and of predicted worker protection with consideration to the facility cost and to optimize the placement of the detectors in the hazardous material facilities. The numerical analysis method used in this study provides important information that is possible to be validated with an experimental technique of gas tracer measurement method at Los Alamos.

The solutions were obtained on an 866 MHz, dual processors, Dell Computer Corporation, Dell WORKSTATION PWS420 machines. The steady state solution required about 2 days and 5 hours using dual processor of one machine. The transient analysis required about over 2 days of continuous operation using four distribute parallel processors to obtain all concentration profiles for six detectors with four gas release sources.

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