Retrofit Constant Speed Fan Laboratory Exhaust Systems Using Multi-Stack and Variable Speed Drive Techniques

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All industrial, university, and other institutions that conduct chemical or biological testing and experiments use fume hoods, which guide polluted air into exhaust systems. Exhaust systems send polluted air to outside of buildings. Exhaust systems must prevent unsafe toxic contaminant concentrations in inhabited areas outside of buildings. In most building designs, stack heights are often limited in order to satisfy architectural requirements. To satisfy both architectural and safety requirements, constant speed fan exhaust systems are often selected.

The constant speed fan exhaust system maintains a constant stack exit velocity using a constant speed fan and make-up air. The stack exit velocity depends on stack heights, wind speeds, and other parameters. The detailed design criterion can be found from ASHRAE Applications Handbook. The fan is sized to maintain the required negative static pressure at fume hoods and the required stack exit velocity under the design airflow condition. A make-up air damper is attached at the inlet of the exhaust air fan. When the laboratory exhaust airflow equals the design value, the makeup air damper is closed. The makeup air damper allows outside air to flow directly into the fan inlet to maintain the negative static pressure set point when the laboratory exhaust is less than the design value. Thus a constant speed fan exhaust system maintains the stack exit velocity at the design value or higher, regardless of the laboratory exhaust airflow rate.

A number of studies have shown that significant makeup air is used at all the times in existing laboratory exhaust systems. A comparison was done of the actual laboratory exhaust airflow and the design exhaust airflow in an industrial research laboratory building which had 56 constant-exhaust fume hoods. The investigation found that the actual laboratory exhaust airflow varied from 21% to 43% of the design value during typical working days. Obviously, significant makeup air was used continuously. Laboratory exhaust airflow was measured continuously for over a month in three laboratory buildings where VAV fume hoods were used. It was that the laboratory exhaust airflow varied from 31% to 57% of the design airflow in building 1, 29% to 53%

in building 2, and 45% to 70% in building 3. However, engineers must size the exhaust system using the conventional value to ensure system reliability during its lifetime since the maximum laboratory exhaust airflow may change from year to year. Thus the constant speed fan exhaust systems always use a significant amount of makeup air regardless of the type of fume hoods used in laboratories.

Recently, an investigation was conducted of the fan airflow versus the laboratory exhaust airflow in constant speed fan exhaust systems. When the laboratory exhaust airflow is less than the design value, the fan airflow is *higher* than the design value. The excessive airflow (difference between the fan airflow and the design airflow) increases as the laboratory exhaust airflow decreases. The fan power under lower laboratory exhaust airflow conditions is often higher than the design fan power. Consequently, it has been proposed to use variable speed drive (VSD) technology to limit the fan power at the design value when the laboratory exhaust airflow is lower than the design value. Theoretical analysis shows that the use of a VSD can significantly reduce annual fan energy consumption. The integration of the multi-stack and the VSD techniques decreases the fan energy consumption and prevents noise problems at fume hood air valves under partial laboratory exhaust airflows.