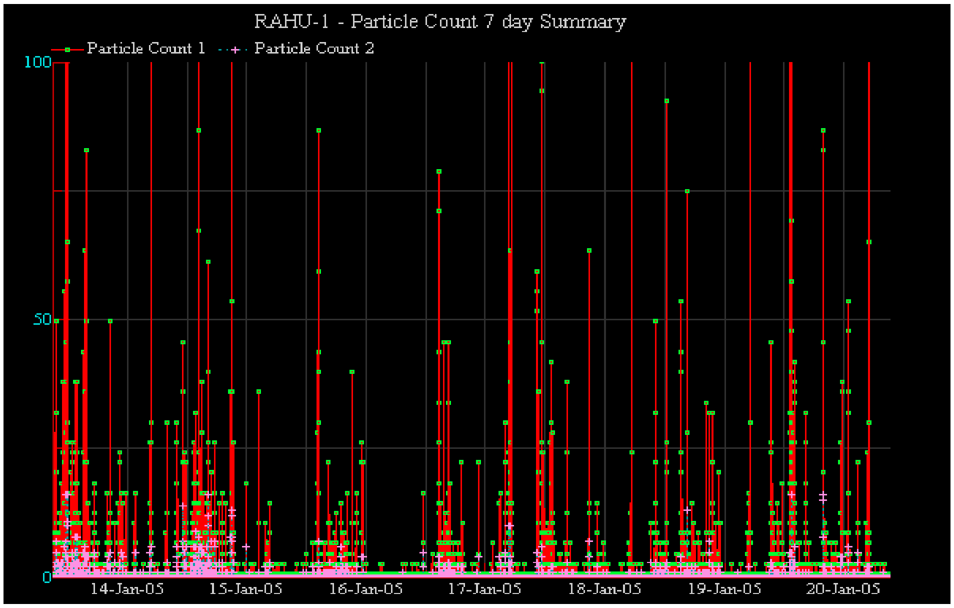
HVAC Air Systems

Demand Controlled Filtration



Summary

Recirculation air flow in cleanrooms has traditionally been determined through various methods. There are several published recommended ranges of airflow which present differing recommendations including ASHRAE Applications Handbook chapter 16 (table 2), IEST Recommended Practice 012.1, and ISO 14644-4 Annex B, however, these and other sources provide conflicting recommended ranges of air change rates and the range of values is very broad. Air change rates have been determined based upon historical rules of thumb, that which was previously successful for similar contamination control situations, or pure guesswork.

Contamination control is the primary consideration in cleanroom design, however the relationship between contamination control and airflow is not well understood. Contaminants such as particles or microbes are primarily introduced to cleanrooms by people although processes in cleanrooms may also introduce contamination. During periods of inactivity or when people are not present, it is possible to reduce airflow and maintain cleanliness conditions. Reducing airflow by use of variable speed fans which are normally a feature of recirculation systems is an energy efficiency measure that can save a lot of energy. Even small reductions in airflow can save significant amounts of energy due to the approximately cube relationship between airflow and fan energy. In some situations airflow reduction may be limited by the cooling that the airflow provides to a process, however in many cases airflows can readily be reduced.

There are several methods of controlling airflow in order to achieve "demand controlled filtration". These range from simple use of timers to sophisticated particle monitoring and control. As shown in figure 1, reduction in airflow did not necessarily increase particle counts during a pilot study at LBNL.

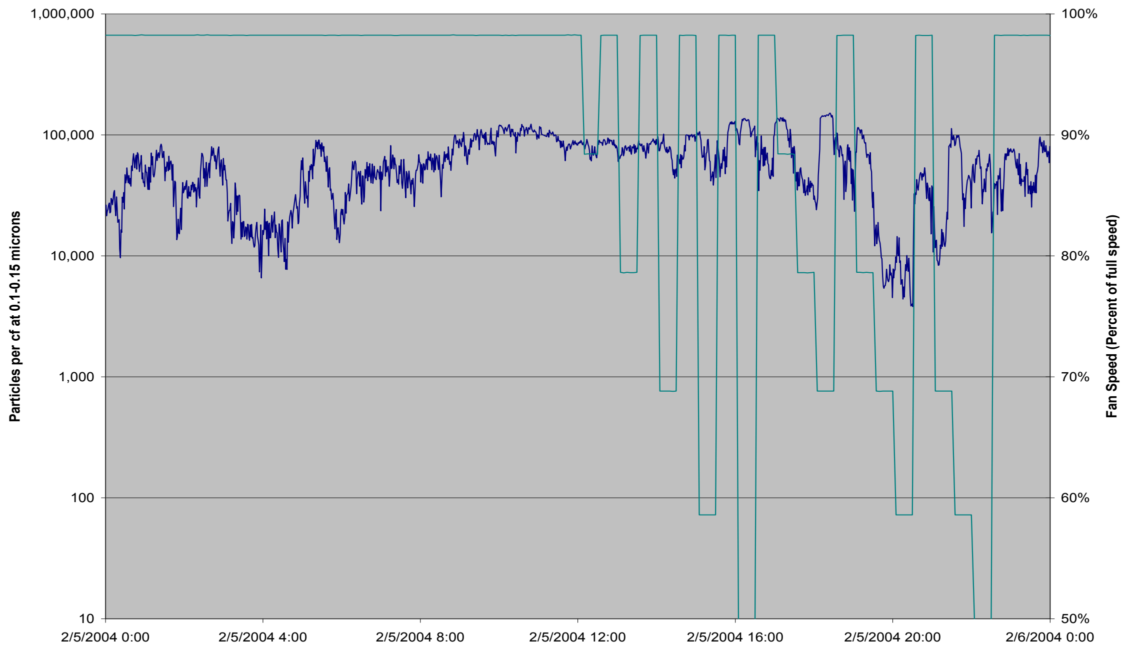


Figure 1. Pilot study airflow reduction and particle counts

Principles

- Reduce recirculated airflow in cleanroom when it is unlikely that particles will be generated
- Optimize airflow for best contamination control by real time particle monitoring and automatic control of the recirculation system

Approach

Recirculation air flow can be determined based upon whatever criteria the cleanroom owner and designer are comfortable with. This may involve selecting design values from published recommended values such as IEST Recommended Practice 012.1, or ISO-14644-4 prior corporate recommendations, or other design guidance. Generally, airflow values from the low end of the recommended ranges will yield acceptable contamination control. Using this design airflow, the recirculation system can be designed including sizing of fans, motors, ductwork, and return air paths. In addition, variable speed fans and a control mechanism must be provided. This design condition will consider the maximum airflow as a worst case requirement for the cleanroom and will allow the airflow to be reduced when appropriate.

Recirculation airflow can be controlled in various ways:

- Use of timers or scheduling software to lower airflow at certain times when the cleanroom is unoccupied and with minimal process activity. This generally would be a step change reduction in airflow when the room is expected to be unoccupied and increased back to higher airflow before room is reoccupied.

- Use of occupancy sensors to lower airflow whenever people are not present in the cleanroom. Placement and time delay of sensors needs to be such as to sense when people have exited or are about to enter the space.

- Use of particle counters to control airflow in the room based upon real-time cleanliness monitoring. In this scheme, particle counters will be deployed to monitor the various sizes of particles of concern for a given cleanroom's contamination control problem. The number and placement of counters will need to be determined through interaction with process engineers and may involve some experimentation. An output signal from the particle counters can directly control recirculation fan speed.

System pressurization is an important factor in implementing an airflow reduction strategy. It's important to note that the makeup air system and exhaust systems will continue to operate at their normal levels. This is usually necessary for safety considerations although there may be certain types of cleanrooms where these systems airflow could be reduced as well. A review of system effects should be performed to ensure that desired pressurization levels can be achieved with any reduction of cleanroom airflow.

Consideration of process equipment heat loads may limit the amount of airflow reduction. Airflow could be separately controlled to provide adequate airflow for heat removal, or simply set to always provide adequate airflow.

Real World Experiences (Benchmarking Findings/Case Studies)

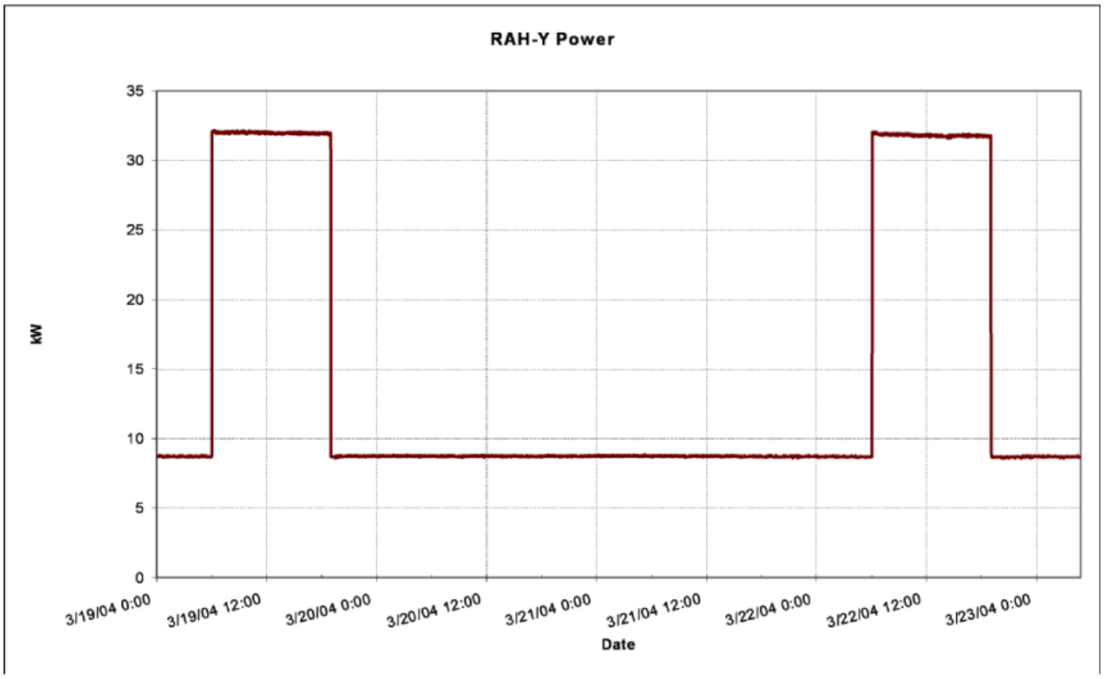


Figure 2. LBNL Benchmarking Study - Measured Recirculation Reduction

The figure above shows the reduction in fan power for a cleanroom where a timer was used to set back airflow when the cleanroom was unoccupied at night and on weekends. The air change rate was reduced from 594 ACH to 371 ACH to achieve this reduction. Another case study showed similar reduction in fan power as shown in Figure 3 below.

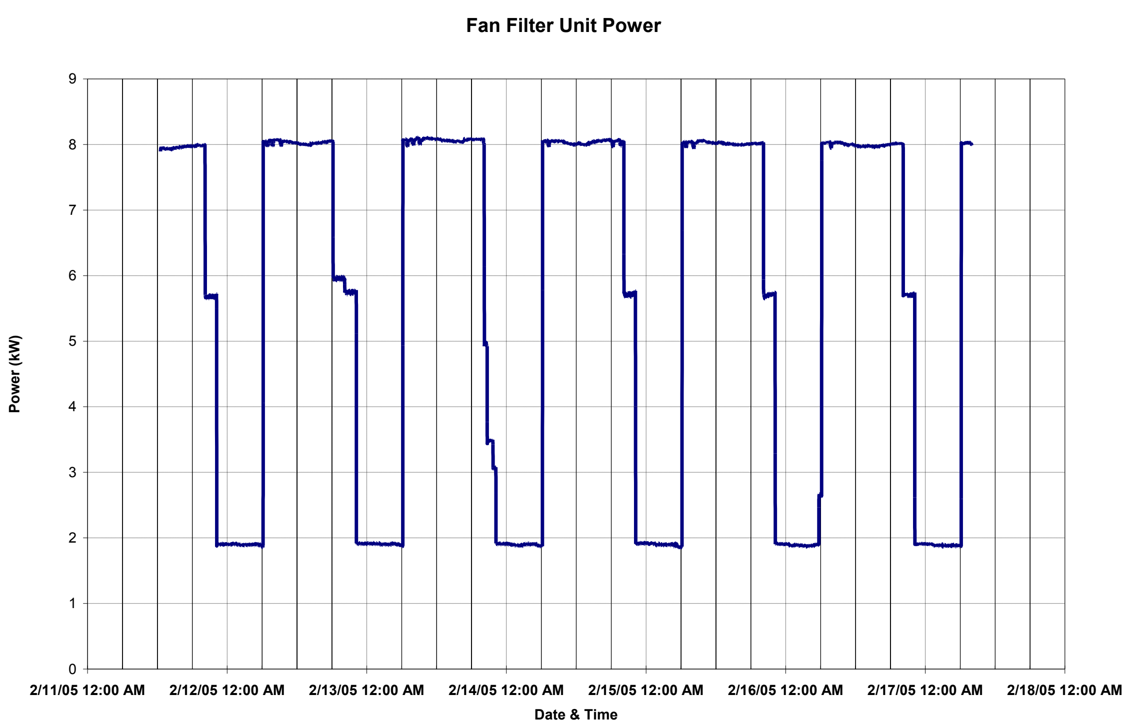


Figure 3. Recirculation fan power reduction in Facility K

Related Best Practices

Recirculation System Types
Air Change Rates
Right Sizing
Fan Filter Efficiency

References

2)

Resources

- Tschudi, William; Faulkner, David; Hebert, Allan; "Energy Efficiency Strategies for Cleanrooms Without Compromising Environmental Conditions" ASHRAE Symposium, June, 2005.

- Xu, Tim, "Performance Evaluation of Cleanroom Environmental Systems," *Journal of the IEST,* Volume 46, August 2003.

- Jaisinghani, Raj, "New ways of thinking about air handling," *Cleanrooms* magazine, January 2001.

- Faulkner, D., Fisk, W. J., and Walton, T.. Energy Savings in Cleanrooms From Demand-controlled Filtration. LBNL-38869.