Noise of Cleanroom Recirculation Air Systems

Mei Q. Wu and Colin G. Gordon

Abstract: The commonly used recirculation air systems for microelectronics cleanrooms are described in this paper. The sound attenuation along the air flow paths are discussed along with noise control concerns. Also presented are the typical sound pressure levels measured in operating cleanrooms.

INTRODUCTION

Cleanrooms used by the micro-electronics industry in the fabrication of integrated circuits typically have up to 600 air changes per hour. The ceilings are up to 100% covered with High Efficiency Particle Air (HEPA) filters or Ultra Low Penetration Air (ULPA) filters running at 80 to 100 feet per minute (1). Such cleanrooms handle about 100 times the air quantity carried by a normal commercial building. For obvious reasons, about 90% of the air is recirculated. Cleanroom noise levels generated by recirculation air systems lie typically in the range NC-55 to NC-65. Excessive noise levels can degrade the performance of production and test equipment. They also interfere with speech and telephone uses and add generally to the environmental discomfort suffered by personnel. Predicting and controlling noise from recirculation air systems is a significant part of cleanroom design.

TYPICAL RECIRCULATION AIR SYSTEMS

Commonly used recirculation air systems include packaged air handlers, fan-tower units, and fan-filter units.

Packaged air handlers usually include a centrifugal or plug (plenum) fan packaged with pre-filter and cooling coil in a sheet metal enclosure. Air flow ratings lie typically in the range 15,000 to 30,000 cfm. The air handlers are generally located at the fan deck level directly above the cleanroom. Supply air from each air handler flows to the individual filters via short flexible or sheet metal ducts. Return air flows through the perforated raised access floor through return air chases back to the air handler. Usually there is little space for noise control outside the air handler itself. The noise levels in a cleanroom are determined largely by the sound power levels radiated from the discharge and inlet of the air handler. Figure 1 shows the range of octave band sound pressure level spectra measured in a cleanroom that utilizes packaged air handlers. These measurements and the measurements given in Figures 2 and 3 were taken prior to start-up of process “tools” that manufacture the microelectronic product. Process tools, of course, can add appreciably to the noise levels in an operating cleanroom.

Fan-tower recirculation air units consist, most often, of vertically-mounted vaneaxial fans arranged along the cleanroom perimeter. Air flow ratings commonly lie in the range 50,000 to 120,000 cfm. The supply air flows upwards before making a 90° turn, into a pressurized plenum above the cleanroom filters. The return air flows through the raised access floor and the “transparent” structural floor into the “clean” sub-fab from which it returns horizontally to the intake plenum of the fan tower. Silencers are used in the supply and return air paths of the fan tower. Figure 2 shows the range of sound pressure level spectra measured in a typical cleanroom that utilizes fan-tower recirculation air systems.

Fan-filter units combine a single filter, normally 2 x 4 feet, with a small direct drive blower. Fan-filter units are supported by the ceiling suspension system. There is no space for noise control outside a unit. Therefore it is important to select a unit which will meet the desired noise criterion. A separate paper is presented by the authors that discusses the noise and vibration characteristics of fan-filter units (2). Figure 3 shows the range of sound pressure level spectra measured in one relatively quiet cleanroom supplied using fan-filter units.

DESIGN CONCERNS

Usually there is very limited spaces for noise control in a recirculation air system. Noise control is further hindered by general reluctance to use fibrous materials which could shed particulates into the air stream. A final contributor to the noise problem is the cleanroom itself which must be hard-surfaced and configured to prevent retention and build-up of particulates. Without careful noise control, a recirculation air system can cause noise levels up to NC-75 in the cleanroom. High noise levels can cause some micro-electronics tools to malfunction. High noise levels maybe difficult or impossible to correct once a recirculation air system is installed. Therefore it is critical to address noise issues at an early design stage.

We usually recommend a noise criterion of NC-55 or NC-60 for recirculation air systems. With a noise criterion established, a critical part of the noise control consultant's work is to specify the allowable sound power levels for the recirculation air units based on the noise criterion, the sound attenuation through the air paths, and the characteristics of the room. It is also important to validate the data submitted by the manufacturer. When necessary, tests are conducted to confirm the sound power levels of the recirculation air units and the insertion losses of the silencers. Standards usually specified for recirculation air unit and silencer testing are AMCA 300 and ASTM E-477, respectively. Substitute testing methods, such as sound intensity method, are used in cases where standard testing conditions cannot be met.

The recirculation air systems are not the only noise source in a cleanroom. The process equipment itself often contributes significantly to the final environment. Figure 4 shows the range of sound pressure level spectra measured in several fully operating cleanrooms.

REFERENCES

1. Gordon, C. G. and Yazdanniyaz, A. M. "Noise Prediction and Control in Micro-electronics and Cleanrooms," Proceedings of Inter-Noise 89, Newport Beach, California, 593-596, 1989.
2. Wu, M. Q. and Gordon, C. G. "Noise and Vibration Characteristics of Cleanroom Fan Filter Units," Proceedings of the Conference on Acoustics, Seattle, Washington, 1998

FIGURE 1. Sound pressure level spectra measured in a cleanroom served by packaged air handlers at start-up.

FIGURE 2. Sound pressure level spectra measured in a cleanroom served by fan-towers at start-up.

FIGURE 3. Sound pressure level spectra measured in a cleanroom served by fan-filter units at start-up.

FIGURE 4. Sound pressure level spectra measured in a fully operating cleanroom.