Toward Green Cleanroom Systems: Energy-efficient Fan-filter Units

Ming-Shan Jeng, Industrial Technology Research Institute (ITRI)
**Tengfang Xu, Lawrence Berkeley National Laboratory (LBNL)**
Chao-Ho Lan, Industrial Technology Research Institute (ITRI)
Presentation Outline

- Introduction
- Purposes
- Approaches
- Results
- Conclusions
- Recommendations
Energy-efficient Fan-filter Units

• Introduction
  – Green cleanroom systems
    • Challenges and benefits
  – Cleanroom energy performance
    • Applications of fan-filter unit (FFU)
    • Opportunities
Cleanroom Energy Use

**Facility 1**
- Office (Lights, Plugs) 9%
- Chilled Water 19%
- Other Misc. 8%
- Process 13%
- Cleanroom Fans 16%
- Hot Water & Steam 23%
- Cleanroom Lights 1%
- Compressed Air & Process Vacuum 6%
- Process 13%
- Other Misc. 8%
- Process 9%
- Compressed Air 7%
- Cleanroom Fans 27%
- Office (Lights, Plugs) 9%
- Total Chilled Water 20%
- Hot Water, Steam and Cafeteria 17%
Energy-efficient Fan-filter Units

- Purposes
  - Introduce the FFU testing standard and its integration with IEST Recommended Practice
  - Evaluate energy performance of 20 FFUs tested at ITRI
    - Present laboratory-testing results
    - Compare unit performance
Energy-efficient Fan-filter Units

• Approaches
  – Principle
    • Laboratory tests to obtain accurate measurements under various operating conditions
  – Control and Method
    • Ancillary fan and damper to control airflow rates across the FFU tested
  – Device Layout
    • FFU to be mounted horizontally or vertically on the exit of the air chamber
Energy-efficient Fan-filter Units

- Approaches – Device Layout
Energy-efficient Fan-filter Units

• Approaches - Partnerships
  – Industrial Technology Research Institute (ITRI)
  – Institute of Environmental Sciences and Technology (IEST)
  – Air Movement and Control Association International (AMCA)
  – SEMATECH International
  – Suppliers and users
  – CA Energy Commission and utility companies
Energy-efficient Fan-filter Units

• Results
  – Performance Curves
    • Airflow, pressure, total pressure efficiency
  – Energy Performance Index (EPI)
    • Power usage normalized by the airflow rate through an FFU
    • A lower EPI value indicates higher energy efficiency
  – 4’x2’ and 4’x4’ FFUs
Energy-efficient Fan-filter Units

4’x2’

Common Speeds

FFU Pressure Rise (Pa)

Airflow Speed at FFU Exit (m/s)

FFU001
FFU002
FFU003
FFU007
FFU009
FFU010
FFU011
FFU013
FFU018
FFU027
FFU028
FFU029
FFU030
Energy-efficient Fan-filter Units

4’x2’

Common Speeds

Total Pressure Efficiency (%) vs. Airflow Speed at FFU Exit (m/s)
Energy-efficient Fan-filter Units

4’x2’
Energy-efficient Fan-filter Units

4’x4’

Common Speeds
Energy-efficient Fan-filter Units

4’x4’
Energy-efficient Fan-filter Units

• Conclusions
  – Use of the procedure
    • Provides comparable performance information
    • Identifies most efficient and functional FFUs
  – Benefits to the industry
    • IEST RP development for FFU testing guideline
    • Utility incentive programs for “greener” FFU systems
Energy-efficient Fan-filter Units

• Recommendations
  – Test additional FFUs
  – Improve FFU designs such as motor types and fan wheels
  – Develop baseline information for utility incentive programs to encourage using efficient FFUs
  – Integrate LBNL procedure into IEST Recommended Practice guideline and establish an international standard