Balancing the Demands of Facility Cost, Redundancy, and Energy Efficiency - When Designing and Constructing a Medical Device Cleanroom Facility

Presented by:
Paul Lukitsch CEM
Energy Manager & Regional Facilities Manager
EMD Millipore Corporation
Danvers, MA, USA
Paul.lukitsch@emdmillipore.com

Our challenge is addressing sustainability across this “disposable” value chain

- Bioscience systems, kits and reagents
- Analytical Reagents
- Process monitoring tools
- Advanced lab water systems & consumables
- Disposable manufacturing & filtration solutions
- Chromatography media
- Pharma raw materials
Life Science leader in creating value responsibly

**Strategic Goals**

**Products**
- Increase Product Sustainability

**Operations**
- Minimize Impacts
- 10% Resource Reduction (GHGs, Water, Waste)

**People**
- Mobilize Employees
- 3 New Awareness Programs

**2015 Targets**

- 10% Sustainable Product Families
- Re.Think
- Re.Focus
- Re.Commit

---

**Project Case Study - Millipore Mobius II**

**Project Overview**
- 10,000 sq ft Cleanroom X 2
- ISO Class 7
- Validated Facility
- Expansion of Existing Product Line within Existing Building

**Project Requirements**
- 24 hr. Operation
- Redundant Systems
- Hard Budget - $250.00/sq ft of clean space ($2.5 million)
- Fast Track
- LEED Gold

**Design Features**
- Redundant MAU System
- Redundant Chillers
- Redundant Recirculation AHU’s
- Variable Airflow
- All Air Handlers on Emergency Generator

---
Challenge to operate cleanrooms efficiently

• Cleanrooms are typically “Set it and Forget it”

• This is a waste of energy
   ……if the filtration and air flow systems are designed correctly they often are cleaner than required.

Ducted Supply Plenum Return Advantage

• Reduce Ductwork 50% from Ducted Supply Ducted Return

• Eliminate Duct Insulation on Supply and Return in Plenum

• Reduce Return Pressure Drop from Ducted Return
Cleanrooms utilize much higher airflow rate than for general purpose building, energy saving potential from airflow rate reduction is significant.

High volume airflows have been utilized to meet FS-209, IEST (RP), & ISO 14644-2 for decades

<table>
<thead>
<tr>
<th>Classification</th>
<th>ISO Class</th>
<th>FS-209 Class</th>
<th>Air Change Per Hour Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>100,000</td>
<td>5 – 48</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>10,000</td>
<td>60 – 90</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1,000</td>
<td>150 – 240</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>240 – 480</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>300 – 540</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>360 – 540</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>360 – 600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>360 – 600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IEST Recommended Practices RP-12

This practice was based on old experience, in which air change rates were arbitrarily selected solely based on room cleanliness classes, leaving little or no room for analysis of the actual contamination generating practices.
Intuitively, ACR should be based on the required cleanliness class and the activities being performed in the space.

Activities that generate high level of dust will need higher AC/H than those that generate at a lower level.

Most design/operating engineers choose to obey the existing guideline to avoid being challenged.

However, to have a scientific justification to save fan energy, airflow modeling/simulation, to have a quantitative tool

Cleanroom airflow rate should be provided as needed instead of picking an arbitrary rate from the table.

Utilizing active particle monitoring can vary airflow by demand utilizing less airflow in times when particle generation is at a minimum due to inactive periods or enhance practices.

Existing Practices and Problems

What did we consider to make it work with our budget?

Reduce the required CFM for cleanliness

Elected to reduce airflow to the lower end of the design parameters from data generated by airflow modeling to simulate normal contamination load requirements. We selected 30 AC/HR. This reduced energy consumption by an average of 50%.

Direct drive fans with 20,000 hr. bearings to reduce maintenance requirements and shutdowns.

Utilized (2) air handlers at 50% capacity each and tied the supply ducting distribution together to provide 50% redundancy.
## Demand Flow Control to Maintain Room Cleanliness

### For Recirculation/AHU Unit
- Single fan with two-speed or three-speed drives.
- Single fan with Variable Frequency Drive for volume control.

### For Fan-Wall Unit
- Turning off a number of fans.
- Variable Frequency Drive for volume control of multiple fans at the same place.

### For FFU Units
- Turning off a number of FFU’s selectively to lower AHR, and maintain airflow as uniformly as possible.
- VFD of volume control for multiple fans at the same place.

## Building Envelope Project – To Achieve LEED GOLD

### Scope
- As a result of a LEED® Gold Project-Enhanced Commissioning Process detected a building envelope problem above our newly constructed Cleanroom.
- Infrared Scanning technology demonstrated lack of insulation R=1.
- Project was developed to upgrade the Building envelope to R=22.

### Benefits
- Natural gas savings. Reduce emissions.
- Eliminated a condensation issues above our Cleanroom.

### Projected Results

### Actual Results
- 854,235 KWh/yr Savings = $45,792 /yrs. Savings
- Cost $ 243,833, Utility Incentive= $10,000
- Simple Payback of 5.1 yrs.

This image shows the conductive heat loss of the concrete roof T’s on the interior side of the roof overhang. Planned future renovations of the exterior façade will eliminate a potential dew point concern on very cold winter days.
Mobius Project – Demand Control Ventilation

- Particle Counters - Controls Air Handling system to save Energy

**Mobius Cleanroom Particle Counters**

kW vs. Time (8 Weeks)

“Set it and forget it”

144,551 kWh / year Savings (motors alone) = 71% Reduction

Savings for 2 cleanrooms $ 51,652/yr

Results - Particle Counts

Note: Alert & Action Limits are set upon European Commissioning Standard: grade “C” For Dynamic operation

Conclusion: The Mobius 2 clean room consistently operates below 5000.
Questions?