



NIST
National Institute of
Standards and Technology
Technology Administration
U.S. Department of Commerce

[measurements, standards, technology]



**NATIONAL
NANOTECHNOLOGY
INITIATIVE**

[nanotechnology leadership]



HDR

[research & development]



**COLIN
GORDON
&
ASSOCIATES**

[vibration / acoustics]







HVAC Design for Nanotechnology Buildings

Ted Zsirai, PE
HDR Architecture, Inc.

BUILDINGS for ADVANCED TECHNOLOGY WORKSHOP

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Nano Research Environment Criteria

- **Temperature and Humidity**
 - 20°C with ± 0.25 to ± 0.01 °C accuracy
 - 40 to 45% RH with $\pm 5\%$ to $\pm 1\%$ accuracy
- **Cleanliness**
 - Class 1000
 - Class 100
 - Class 10
- **EMI Free Environment**
- **Vibration**
 - 3 to 0.2 micrometer/sec

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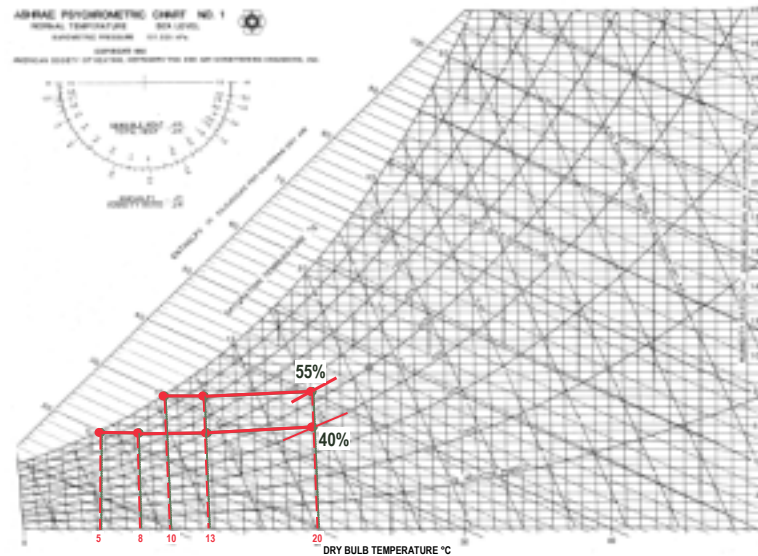
Design Issues

- Conflicting Criteria
- Coordination with Users and Other Disciplines
- Large Space Requirements
- Safe, Reliable, Cost Effective Systems

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Low Humidity Requirements



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Air Filtration

- 30/60% Efficient Pre-filters
- 99.97% Efficient Final Filters
- Gas Adsorption Filters

Noise and Vibration Control

- Need Consultant
- Spring isolators for equipment, ducts and pipes
- Double wall air handling units with silencers
- Minimize airflow velocities in ducts

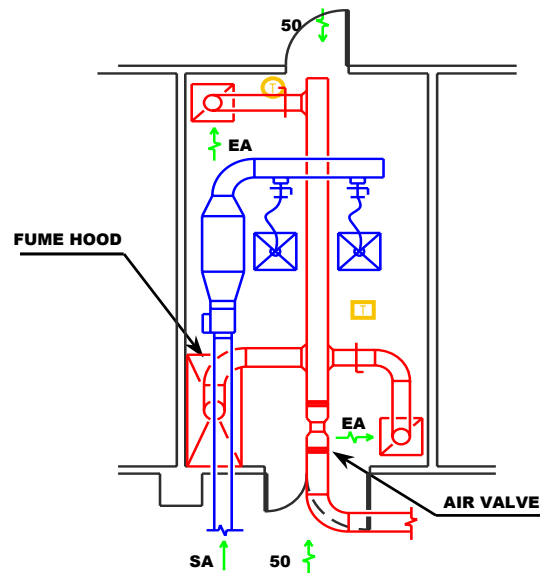
Energy Efficiency

- Coil Loop Heat Recovery
- Chiller Heat Recovery
- Adjustable Frequency Drives

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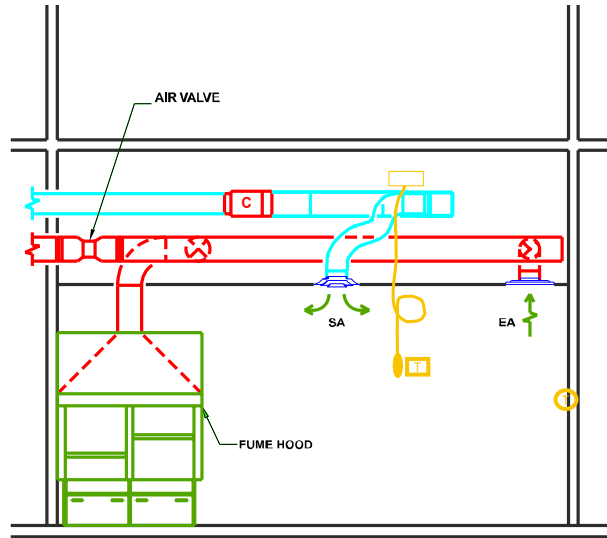
Typical Laboratory Layout



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0.25°C Temperature Controls



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High Accuracy Temperature Controls 0.01 °C

What does it mean?

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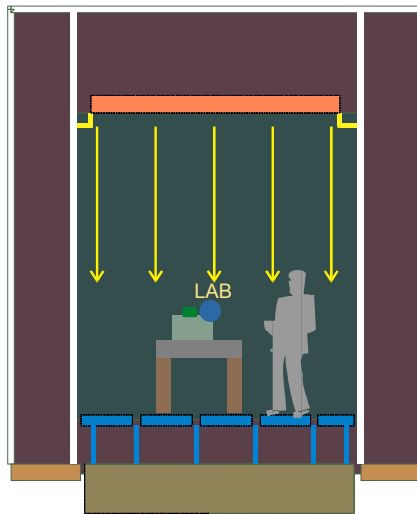
Maximum Permissible Heat Gain

Air Flow (l/sec)	Air Changes	Heat Gain (Watts)
5,000	280	123
4,000	224	98
3,000	168	74
2,000	112	49
1,000	56	25
500	28	12
100	6	2.5

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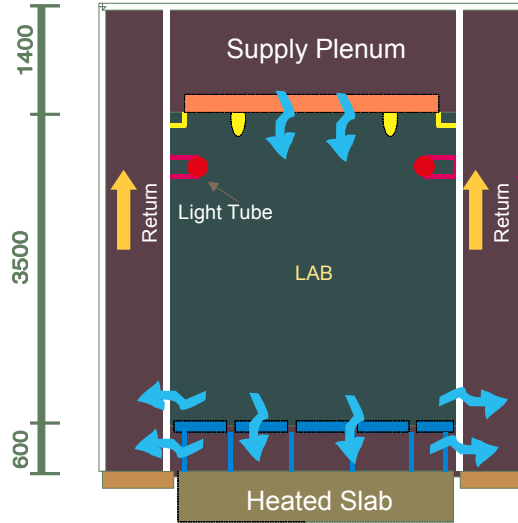
+0.01°C Temperature Control Concept



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+0.01°C Temperature Control Design



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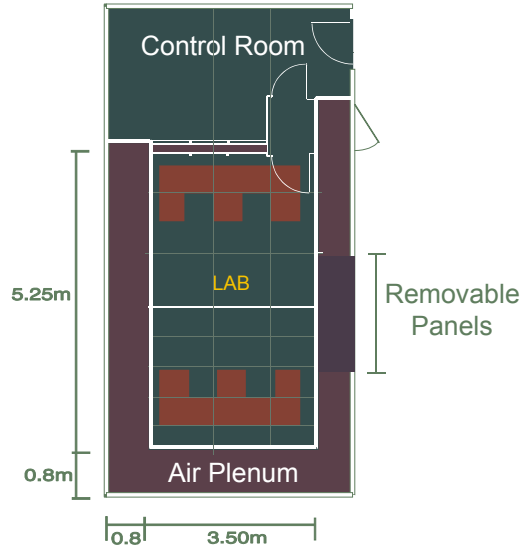
Low Intensity Lighting



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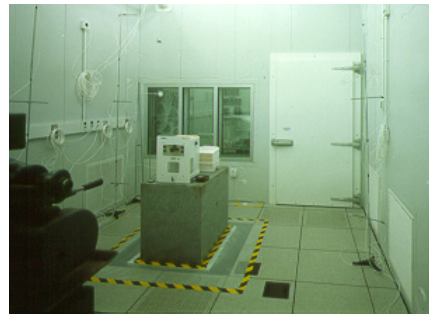
Typical High Accuracy Lab



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Temperature Control Research Project



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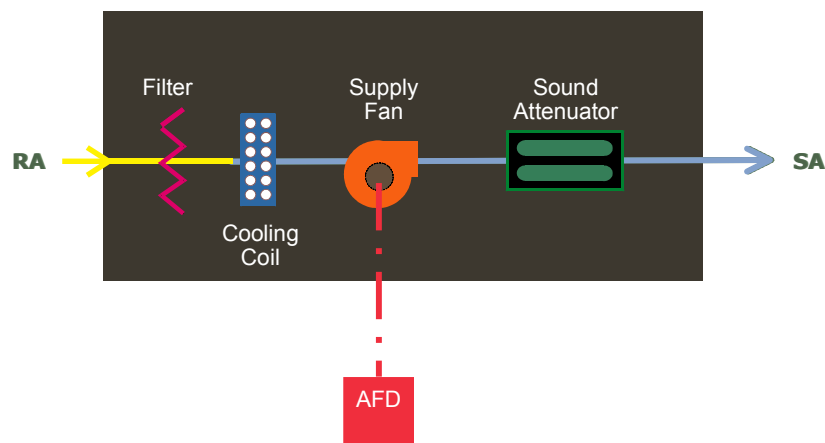
High Accuracy Temperature Control Components

- Circulating Air Handling Unit
- Air Distribution System
- Make-up Air Handling Unit
- Controls

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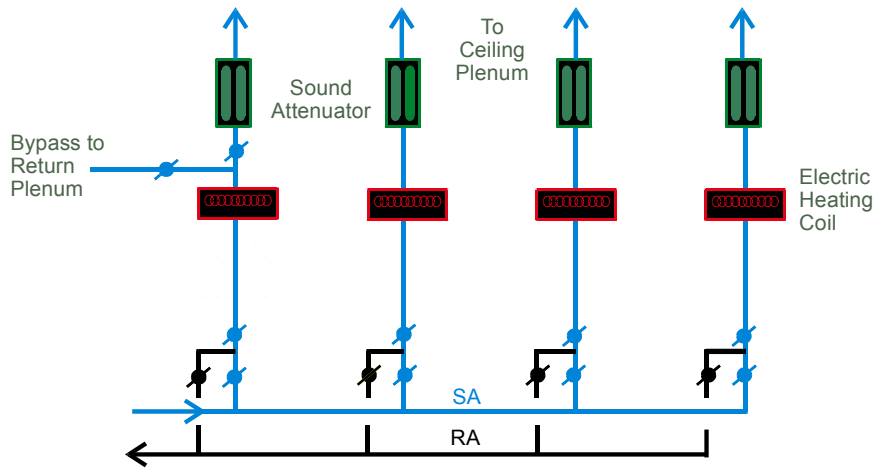
Circulating Air Handling Unit



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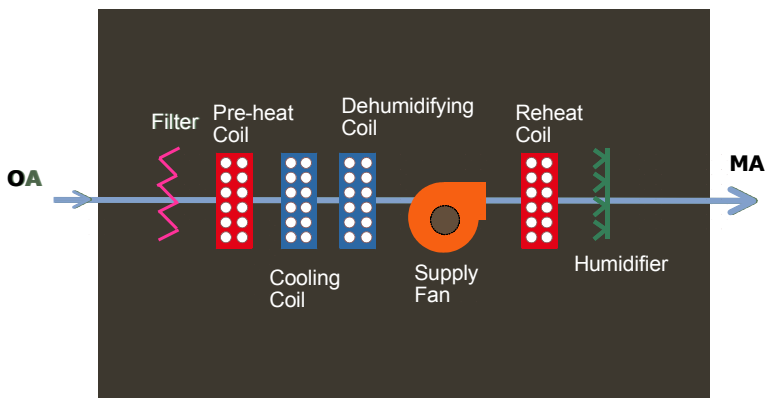
Air Distribution Concepts



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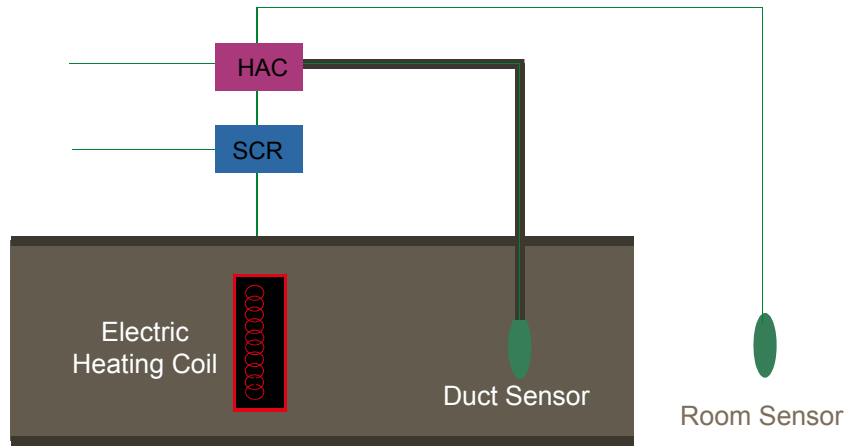
Make-up Air Handling Unit



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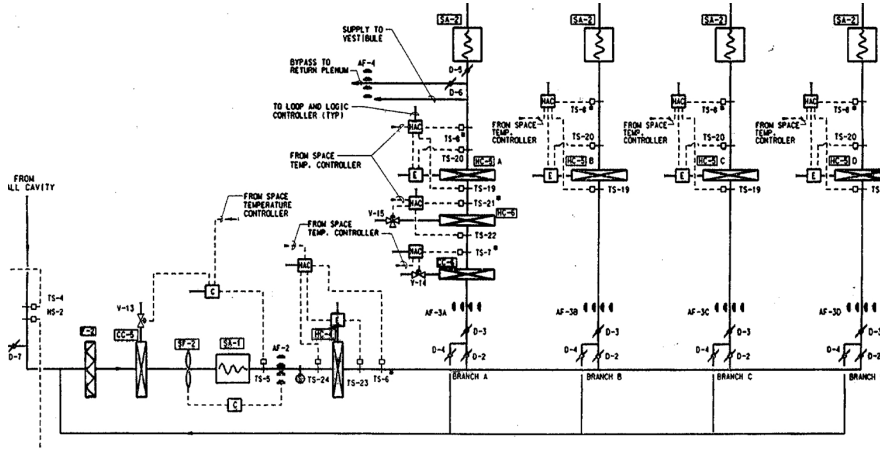
High Accuracy Control Schematic



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High Accuracy Control Schematic



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Temperature Sensors

- Resistance Temperature Detector (RTD)
 - Lower sensitivity
 - More linear
 - Used for wide temperature spans
- Thermal Resistor (Thermistor)
 - Higher sensitivity
 - Low cost
 - High resistance value
 - Fast response time
 - Nonlinear
 - Used for narrow temperature spans

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Temperature Sensor



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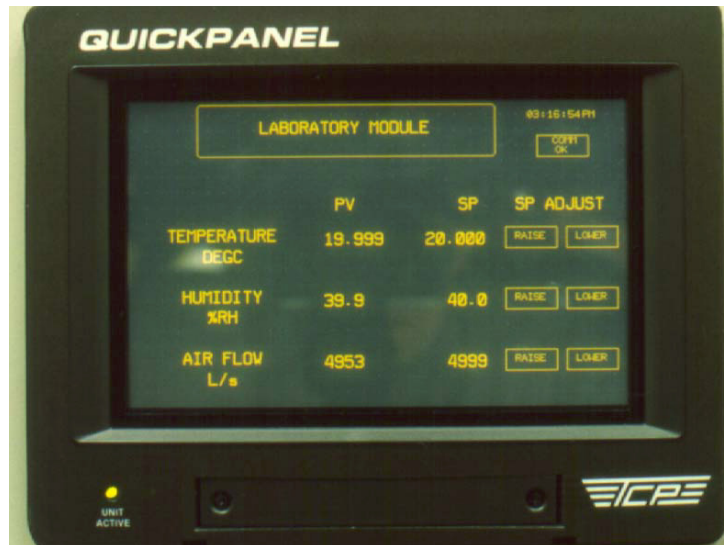
Temperature Controllers



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User's Temperature Control Panel



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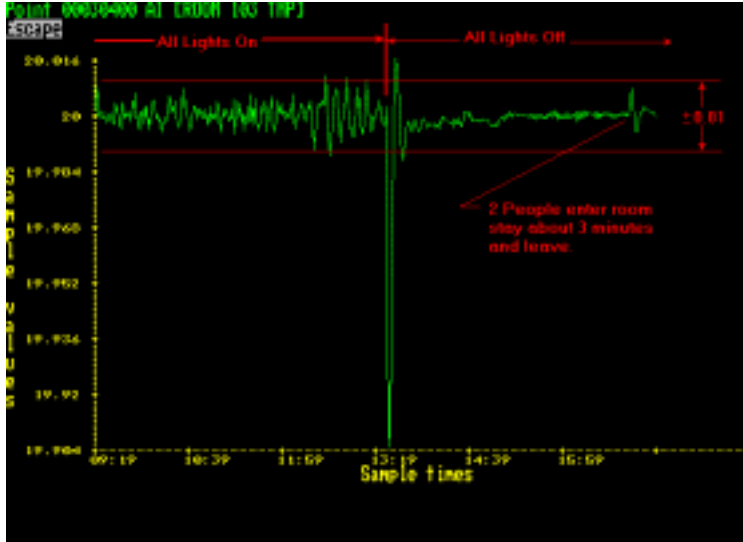
High Accuracy Temperature Control Issues

- Number of Air Changes
 - $\pm 0.01^{\circ}\text{C}$ – 300 AC/HR, 0.3m/s, 120w
 - $\pm 0.1^{\circ}\text{C}$ – 120 AC/HR, 0.12m/s, 475w
 - $\pm 0.25^{\circ}\text{C}$ – 20 AC/HR

High Accuracy Temperature Control Expectations

- Excellent Temperature Stability
- Good Accuracy
- Some Gradient

Test Results



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