The NIST Temperature Controlled Laboratory Module

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Purpose of Research Project

- Proof of design concept
- Evaluation of design alternatives
- Demonstration of feasibility
- Elimination of “fear factor” for potential bidders
- Pre-qualify bidders (4 vendors)

Design Performance Criteria

- Temperature : +/-0.01 C
  - Accuracy
  - Stability
  - Uniformity
- Relative Humidity: +/-2%
- Low Vibration
- Low EMI/RFI

Performance Characteristics

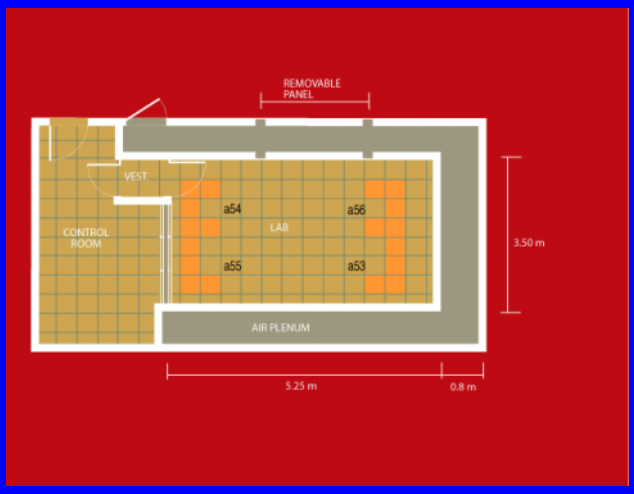
- 1000 to 5000 l/s airflow rate (56 to 280 ACH)
- 15 to 25 C (18 to 22 C tested)
- Isolated floor slab with hydronic control
- Suspended raised floor

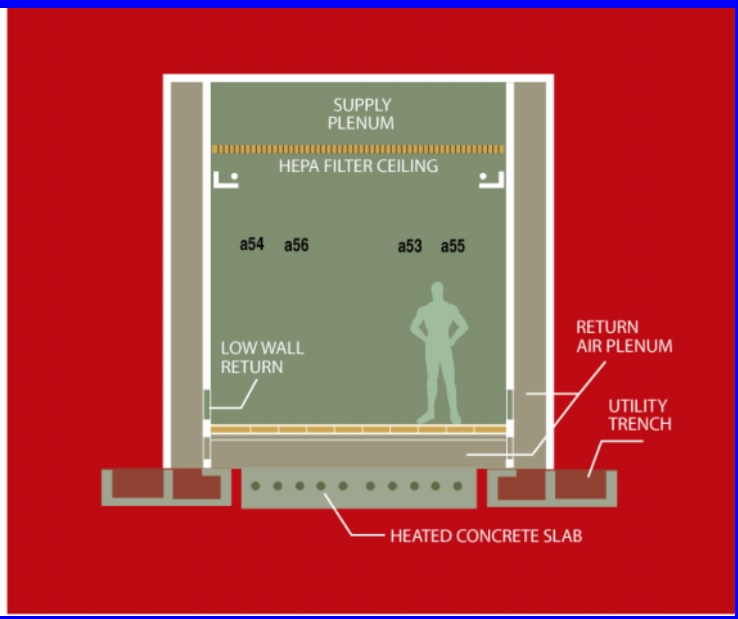
Design Alternatives

- Electric resistance versus hydronic heating in supply ducts
- Single heater versus heaters in each branch supply air duct
- Electric resistance heating versus hydronic heating and cooling of floor slab

Description of Test Module

- Nearly full-scale (approximately 75%)
- Located within a large conditioned space
- Simulated outdoor make-up air
- Adjacent control and instrumentation room
- Independent overlay measurement system for validation


REMOVABLE PANEL
VEST
CONTROL ROOM
a54
a56
LAB
a55
a53
3.50 m
AIR PLENUM
5.25 m
0.8 m


SUPPLY PLENUM
HEPA FILTER CEILING
a54
a56
a53
a55
LOW WALL RETURN
RETURN AIR PLENUM
UTILITY TRENCH
HEATED CONCRETE SLAB

Heat Gain/Loss

- Lighting, people, equipment, envelope
- Convective
  - Dependent on airflow
- Radiant
  - Dependent on surrounding surface temperatures
- Can control by shielding and localized exhaust

Heat Transfer and Temperature

- $\dot{q} = \dot{m} c_p \Delta T$

  where:

  $\dot{q} = heat\ gain$

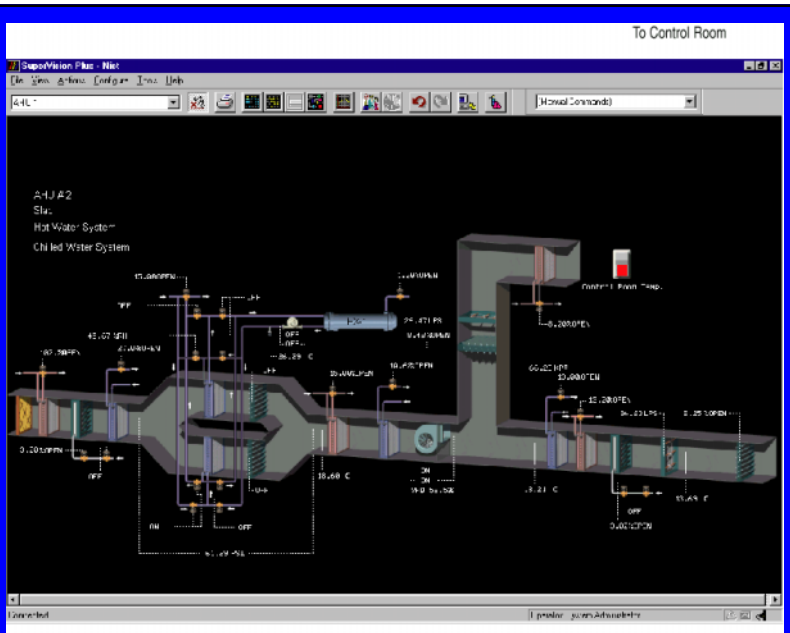
  $\dot{m} = mass\ \ flow$

  $c_p = specific\ heat$

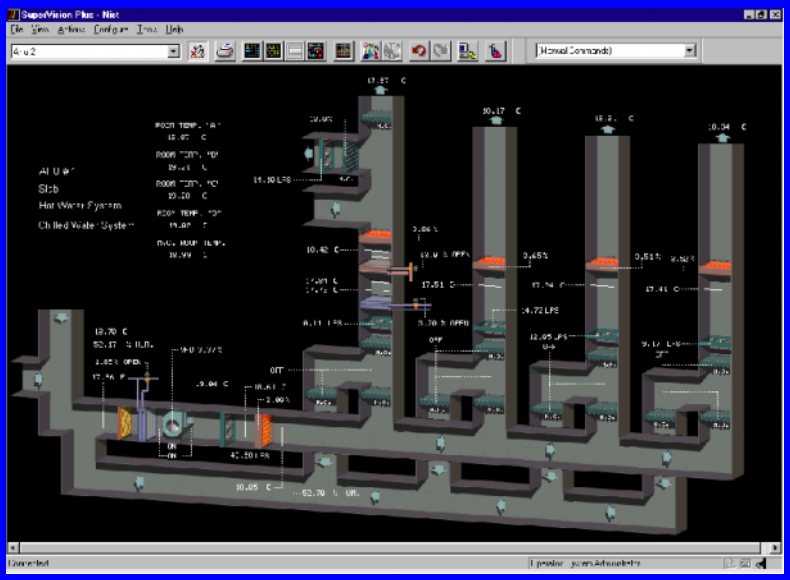
  $\Delta T = temperature\ difference$

Measurement and Control Accuracy and Resolution

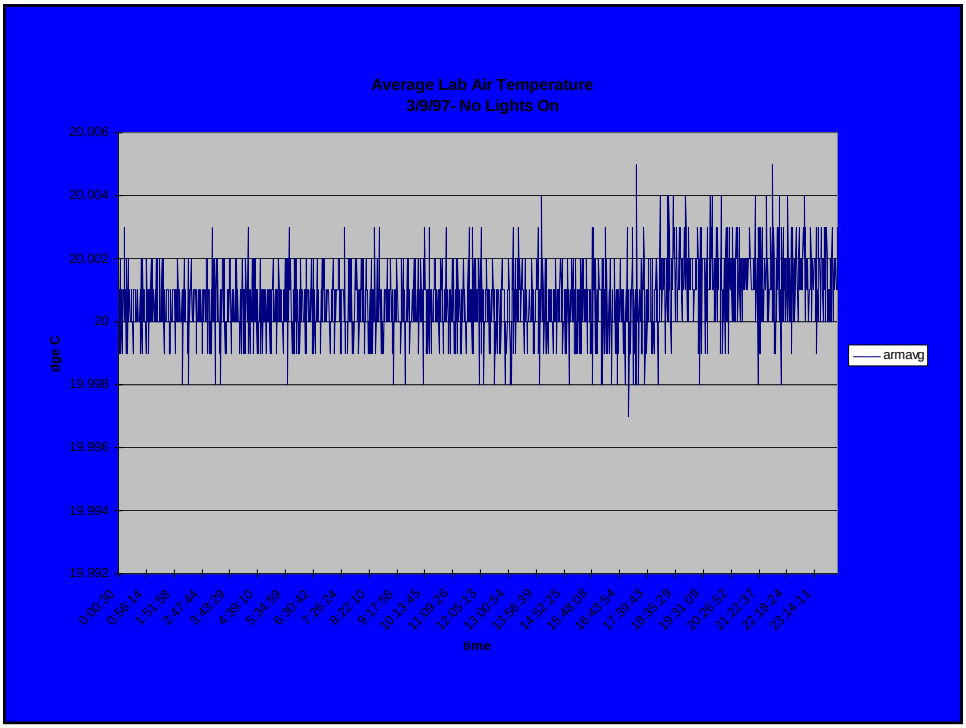
- Overlay measurement system: precision thermistors calibrated to +/-0.001 C
  - 0.001/10 equals 10,000 increments
- Actuators
  - Valves, dampers, heaters

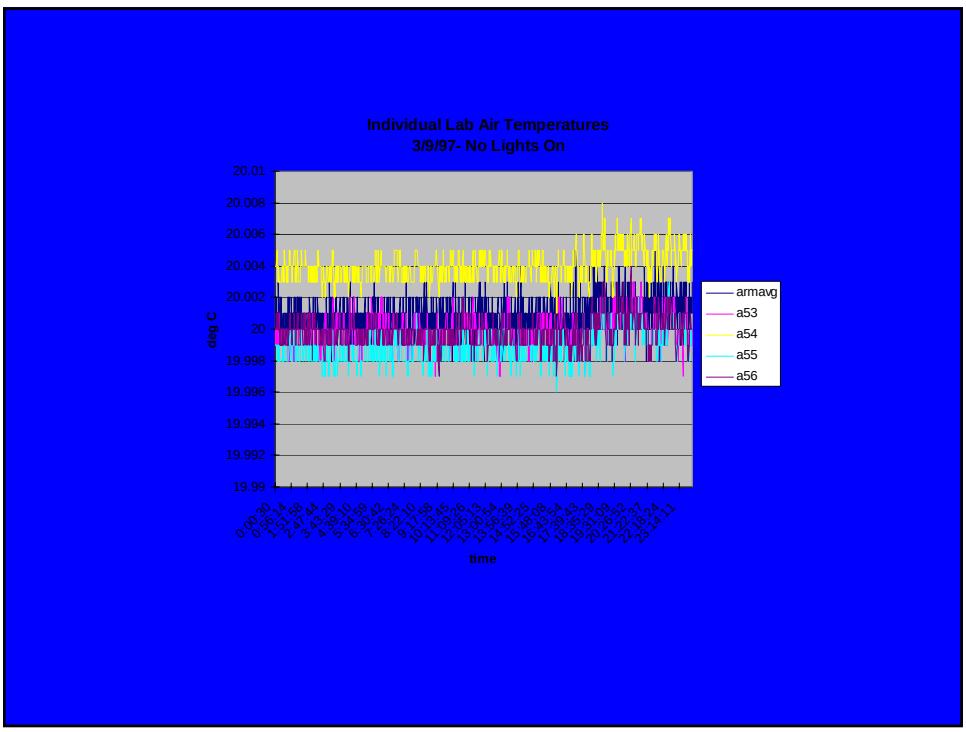


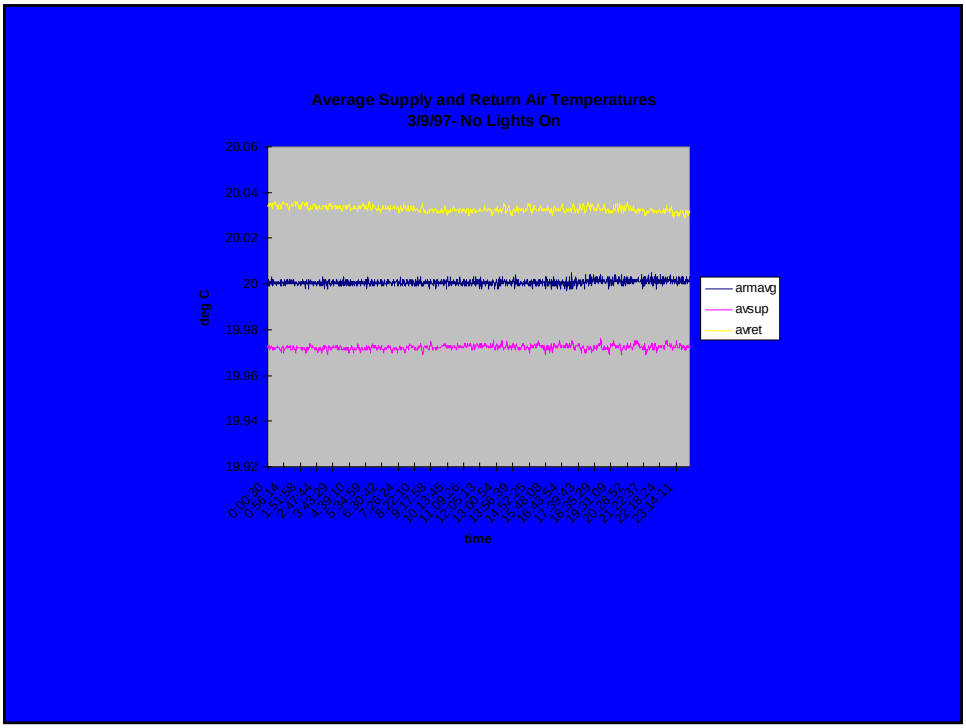
Weathermaker section used to simulate winter and summer design conditions (-18 deg. C to 37 deg. C)

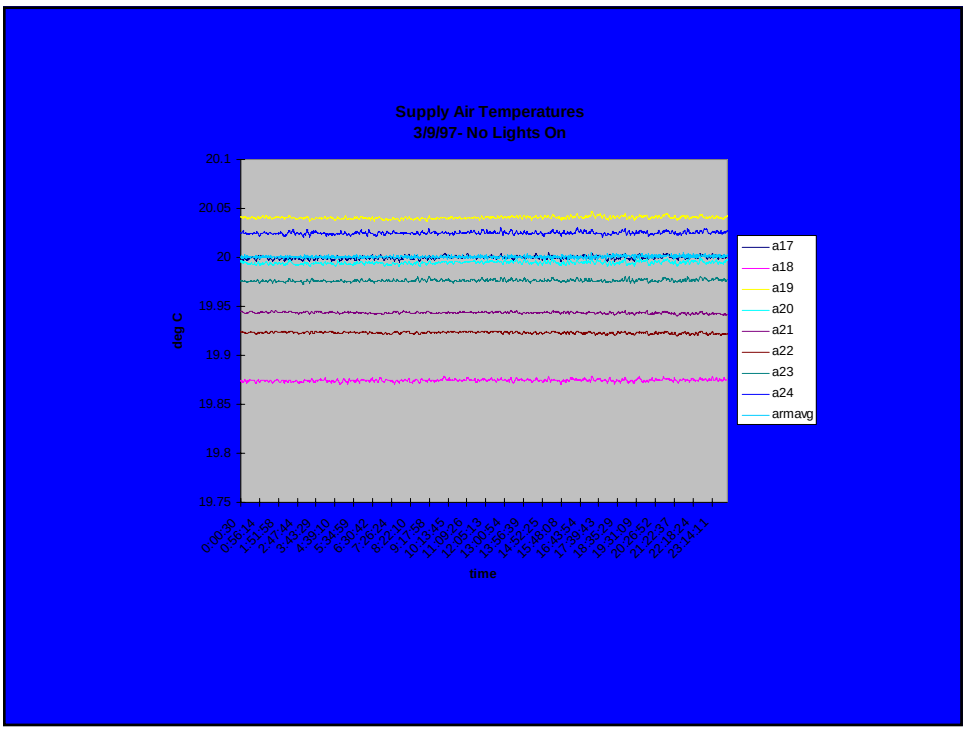


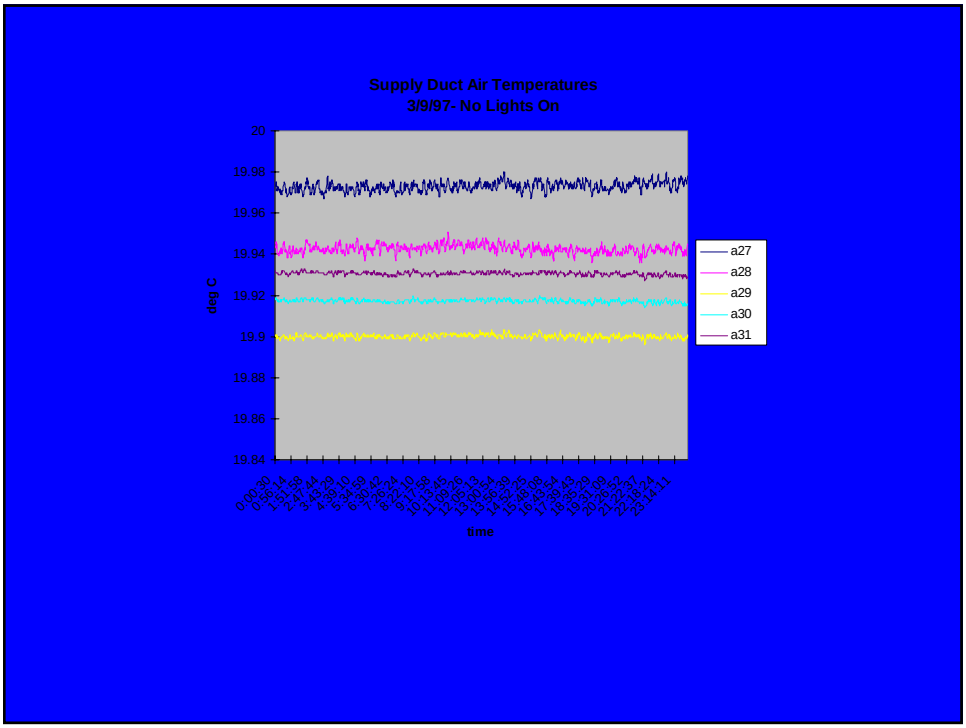
Measurement Results

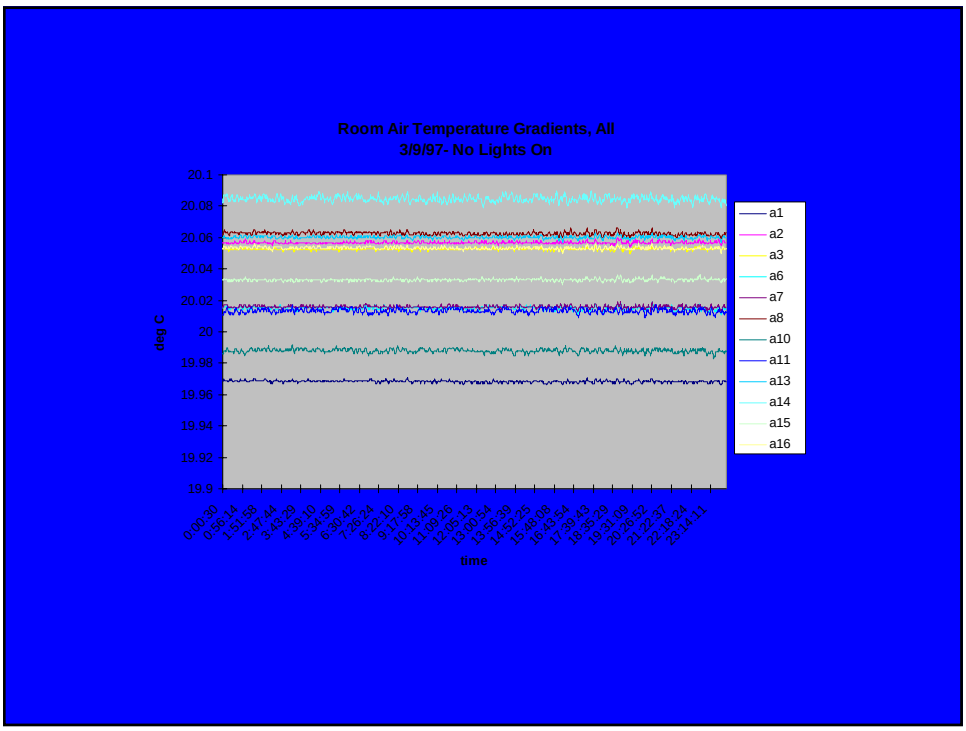

Average Lab Air Temperature
3/9/97- No Lights On
20.006
20.004
20.002
20
19.998
19.996
19.994
19.992
deg C
armavg
0:00:30
0:56:14
1:51:58
2:47:44
3:43:29
4:39:10
5:34:59
6:30:42
7:26:24
8:22:10
9:17:58
10:13:45
11:09:26
12:05:13
13:00:54
13:56:39
14:52:25
15:48:08
16:43:54
17:39:43
18:35:29
19:31:09
20:26:52
21:22:37
22:18:24
23:14:11
time

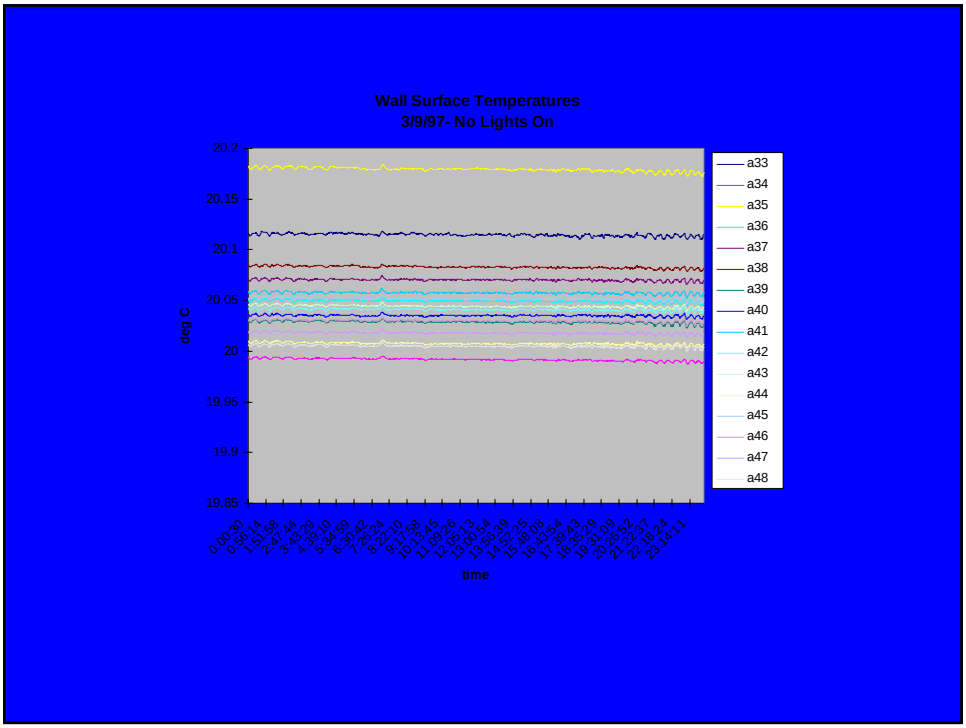

Individual Lab Air Temperatures
3/9/97- No Lights On
20.01
20.008
20.006
20.004
20.002
20
19.998
19.996
19.994
19.992
19.99
deg C
armavg
a53
a54
a55
a56
time

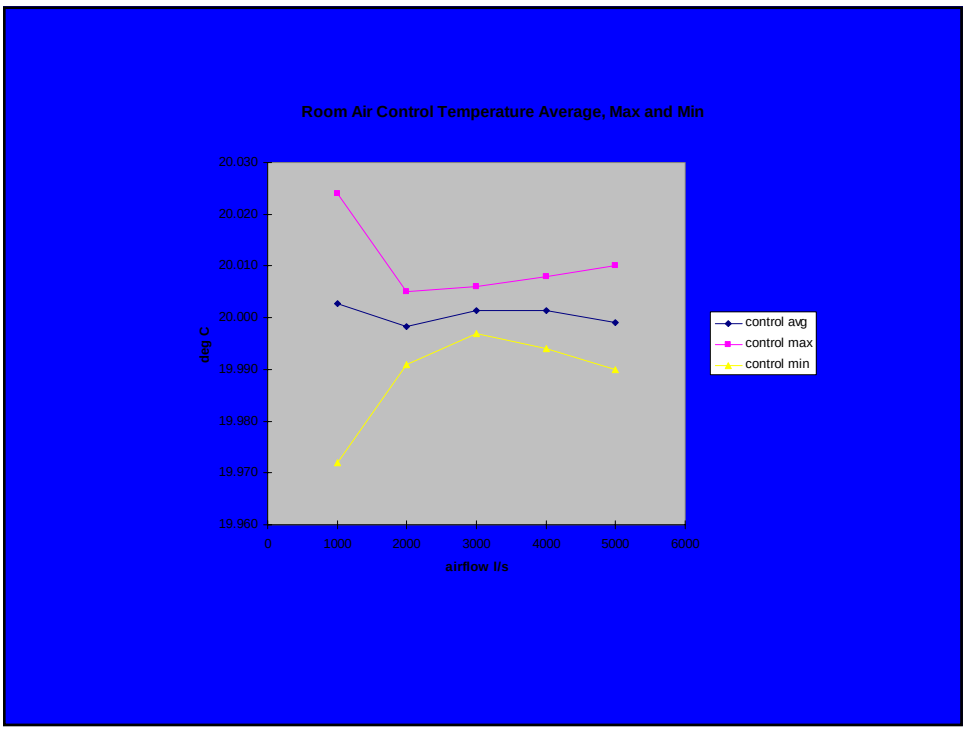

Average Supply and Return Air Temperatures
3/9/97- No Lights On
deg C
20.06
20.04
20.02
20
19.98
19.96
19.94
19.92
armavg
avsup
avret
time

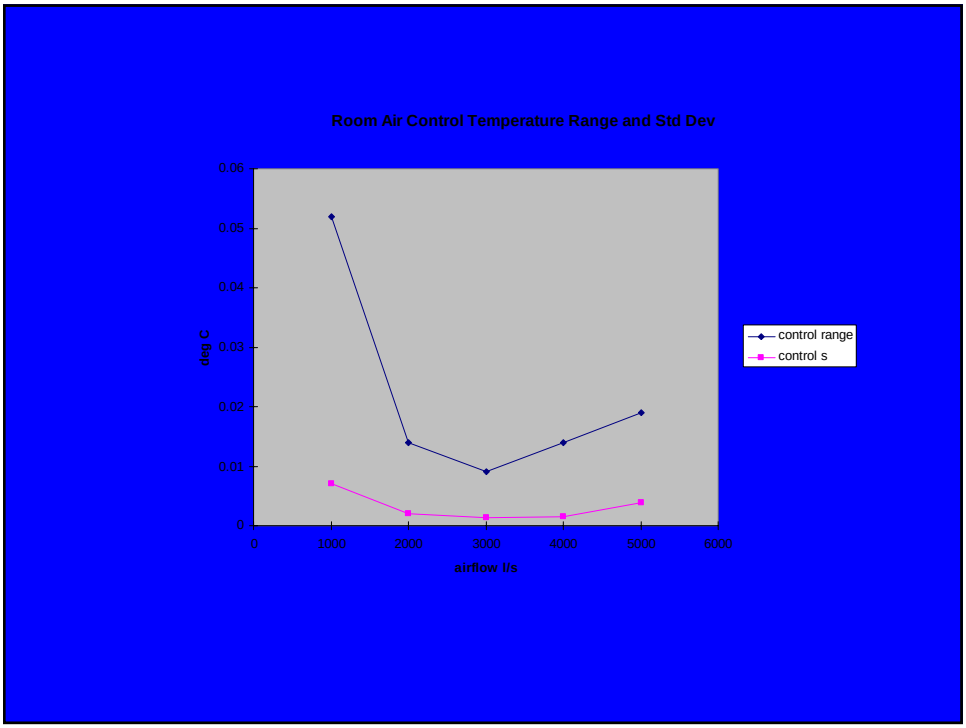

Supply Air Temperatures
3/9/97- No Lights On
deg C
20.1
20.05
20
19.95
19.9
19.85
19.8
19.75
a17
a18
a19
a20
a21
a22
a23
a24
armavg
time

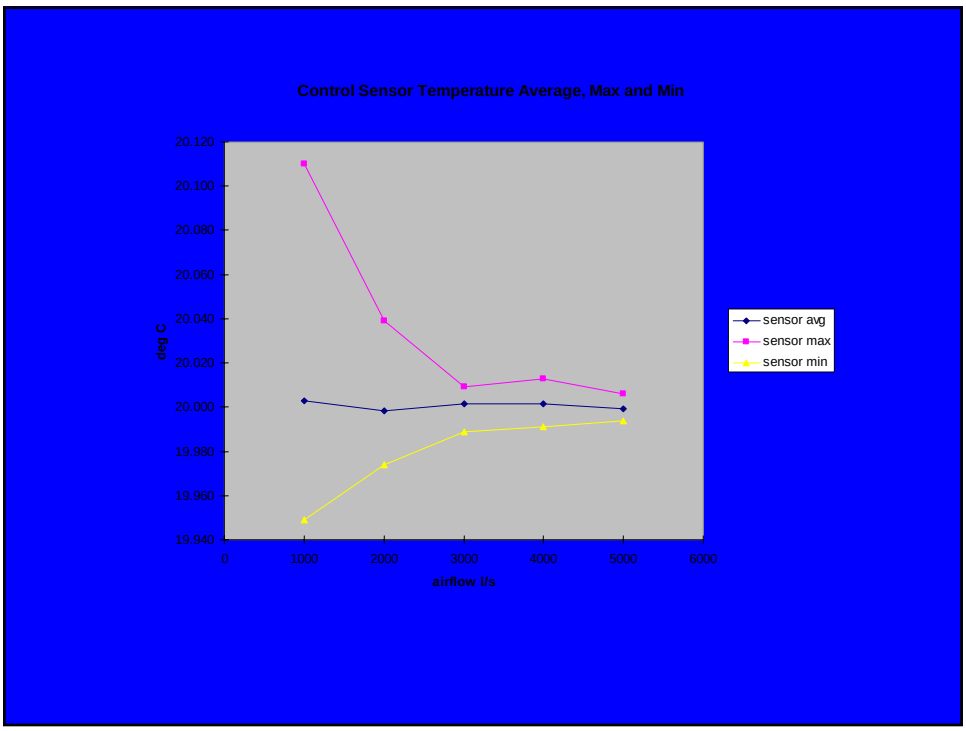

Supply Duct Air Temperatures
3/9/97- No Lights On
deg C
time
a27
a28
a29
a30
a31

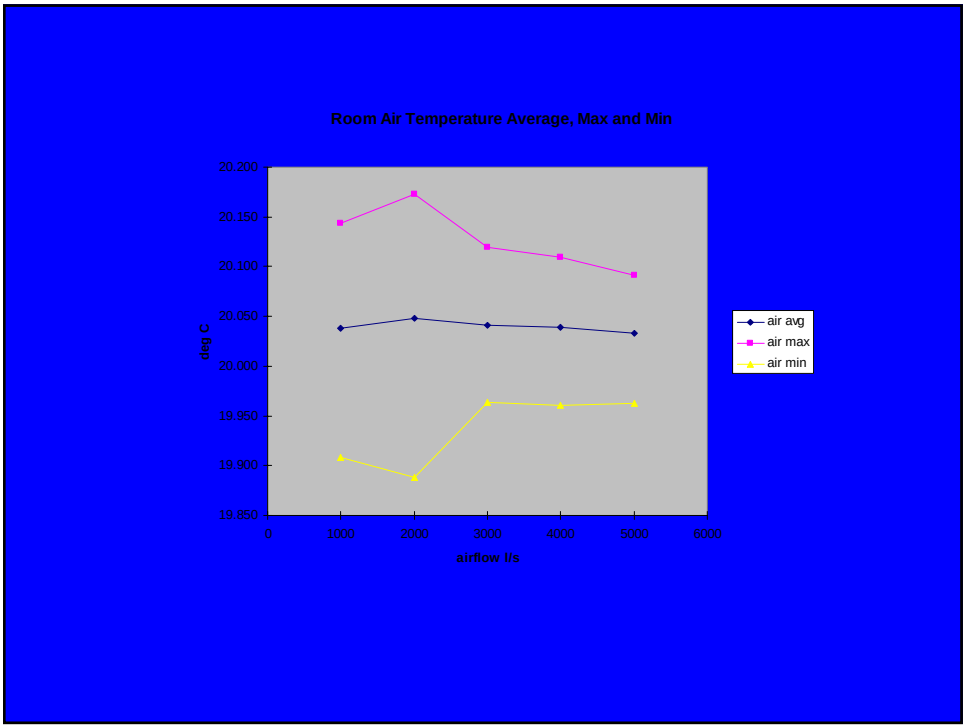

Room Air Temperature Gradients, All
3/9/97- No Lights On
deg C
time
a1
a2
a3
a6
a7
a8
a10
a11
a13
a14
a15
a16

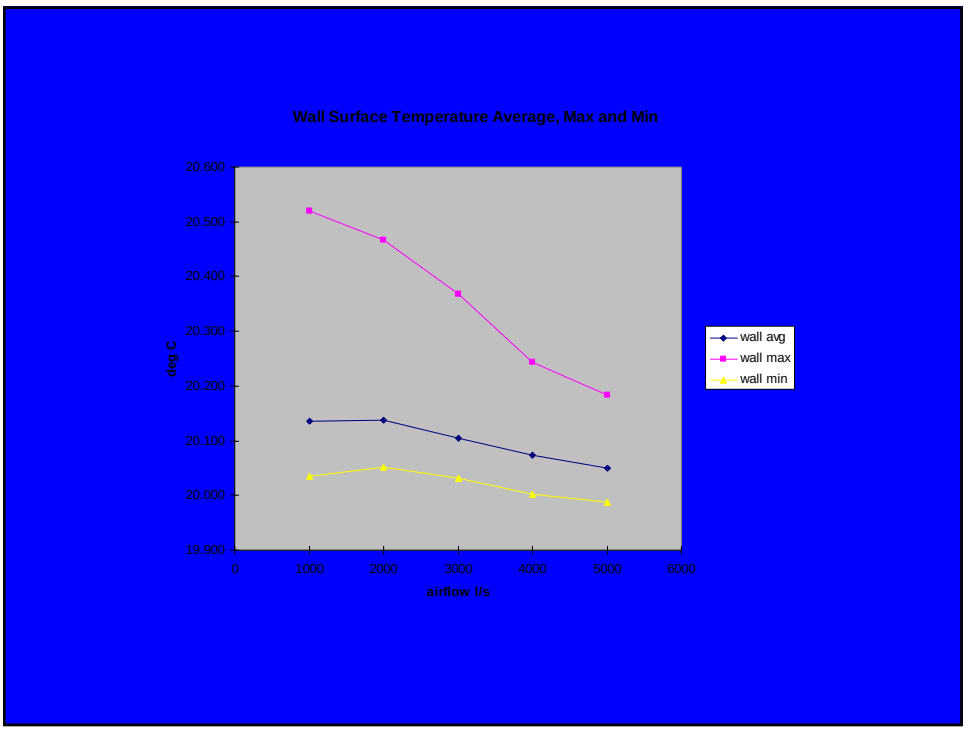

Wall Surface Temperatures
3/9/97- No Lights On
deg C
time
a33
a34
a35
a36
a37
a38
a39
a40
a41
a42
a43
a44
a45
a46
a47
a48


Room Air Control Temperature Average, Max and Min
deg C
airflow l/s
control avg
control max
control min


Room Air Control Temperature Range and Std Dev
0.06
0.05
0.04
0.03
0.02
0.01
0
deg C
0
1000
2000
3000
4000
5000
6000
airflow l/s
control range
control s


Control Sensor Temperature Average, Max and Min
20.120
20.100
20.080
20.060
20.040
20.020
20.000
19.980
19.960
19.940
deg C
0
1000
2000
3000
4000
5000
6000
airflow l/s
sensor avg
sensor max
sensor min


Room Air Temperature Average, Max and Min
20.200
20.150
20.100
20.050
20.000
19.950
19.900
19.850
deg C
0
1000
2000
3000
4000
5000
6000
airflow l/s
air avg
air max
air min


Wall Surface Temperature Average, Max and Min
20.600
20.500
20.400
20.300
20.200
20.100
20.000
19.900
deg C
0
1000
2000
3000
4000
5000
6000
airflow l/s
wall avg
wall max
wall min

Performance Issues

- Non-uniform supply air temperatures
- Room air temperature gradients
- Air temperature stability at low airflow
- Temperature stability versus transient response
- Sizing, tuning and balancing are critical

Conclusions

- Conformance was demonstrated for each of the vendors
- Turbulence-induced vibration was not a problem at high airflows
- Symmetry in airflow design, or task-centered ventilation are beneficial in minimizing temperature gradients
- Uniform supply air temperatures are critical