Optimizing Systems and Operations

Peter Herzog
Herzog/Wheeler & Associates LLP
March 2011

Optimizing Systems and Operations

Goals For This Presentation:

- ✓ Define "Storage Environment Optimization"
- ✓ Demonstrate its potential for:
  - Enhanced collections life
  - Reduced energy consumption
- ✓ Demonstrate how to do it

Storage Environment Management:
Past & Present

Past Environment Management:

Desire for constant temperature and RH

Automated HVAC system controls

"Inexpensive" energy

Resulting Practice: **Set It and Forget It**

Storage Environment Management:
Past & Present

Present Environment Management:

Temperature drift is acceptable
(Cooler is better)

RH drift is acceptable within limits
(e.g., 35% to 50%)

"Expensive" Energy

Emerging Practice: Active Management

Optimizing Systems and Operations

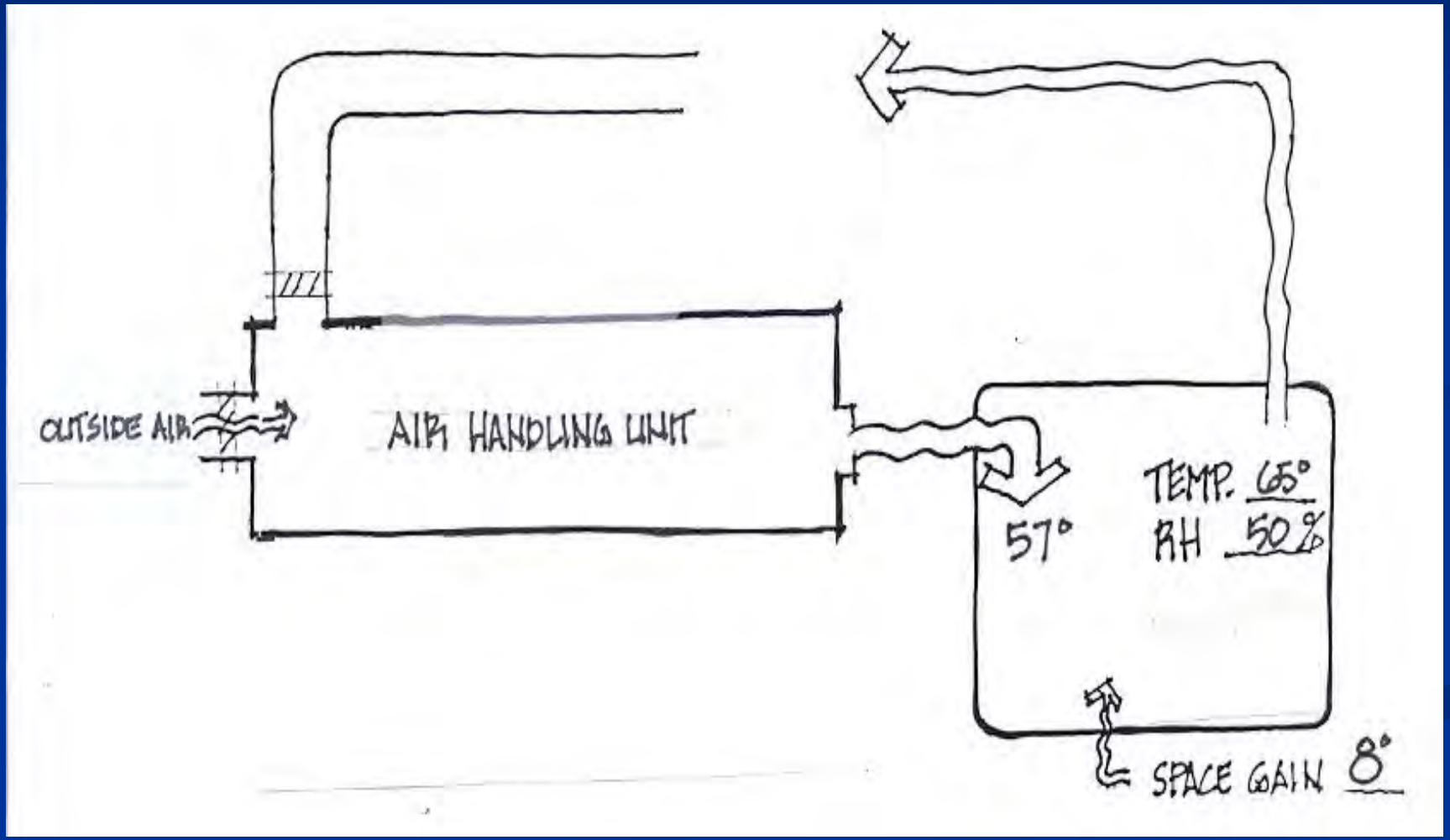
Definition of "Sustained Optimal Storage Environment":

When your unique climate control system consistently produces

Its own best possible storage environment

at the least possible consumption of energy

Collections Storage Climate Control "System"



How Systems Use Energy

Energy = Work Done on a Volume of Air Over Time

Variables:

- How much work

  (Changes to temperature or moisture content)
- How much air
- How much time

Definition of Optimal:

- Best Possible Climate
- While Doing the Least Possible Work
- On the Least Possible Volume of Air
- For the Least Possible Time

How To Optimize

For Each Season of the Year, Day of the Week, or Time of Day Ask:

- Is my existing system producing the best possible climate?
- Is it doing more work than necessary?
- Is it working on more air than necessary?
- Is its time of operation longer than necessary?

How To Answer These Questions:

Collect and Analyze Space Data:

- Measure space temperature & RH
- Use IPI tools to quantify climate

Understand Your Control System & Climate

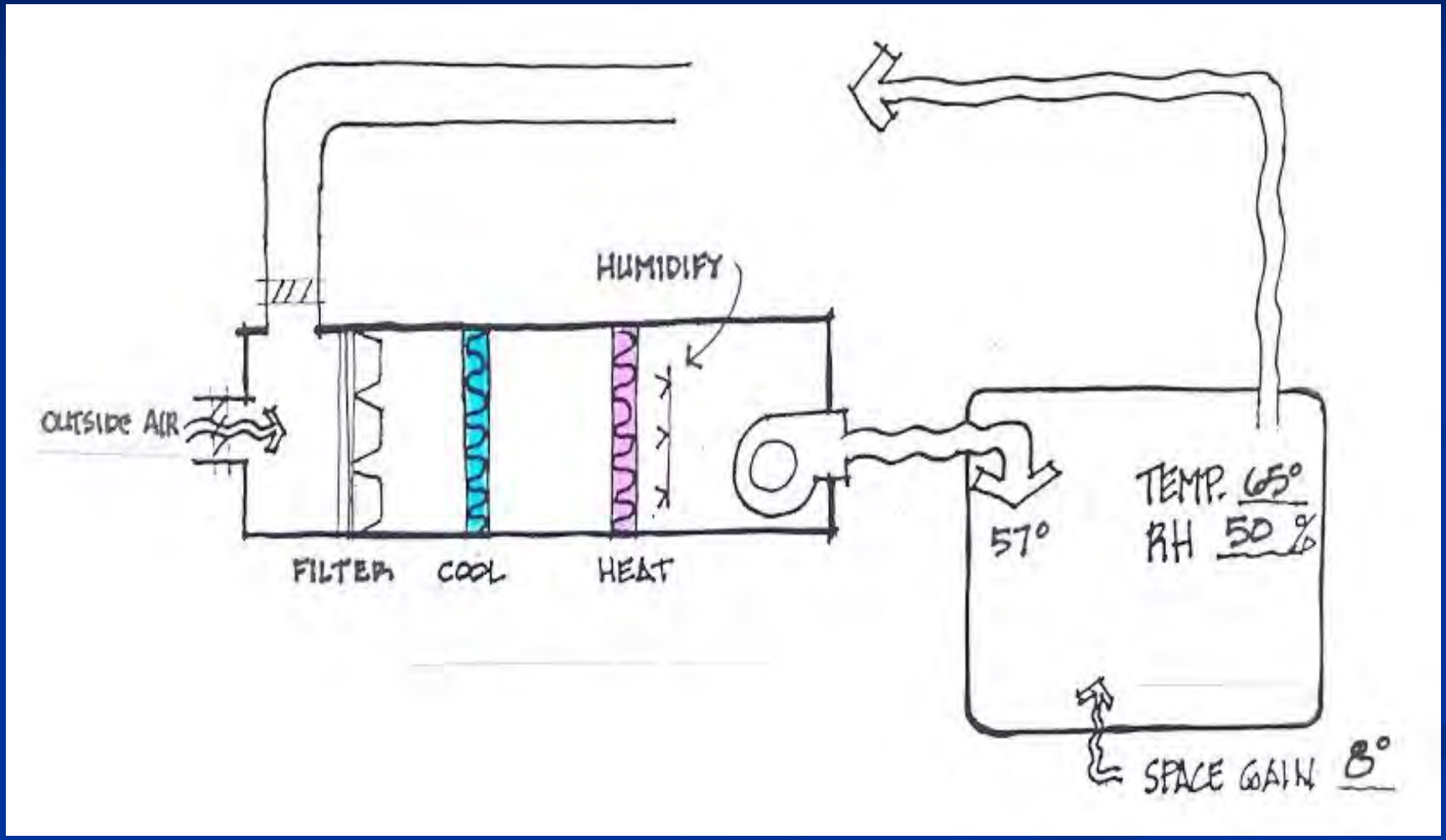
- Draw a cartoon
- Analyze annual weather data

Collect & Analyze Performance Data

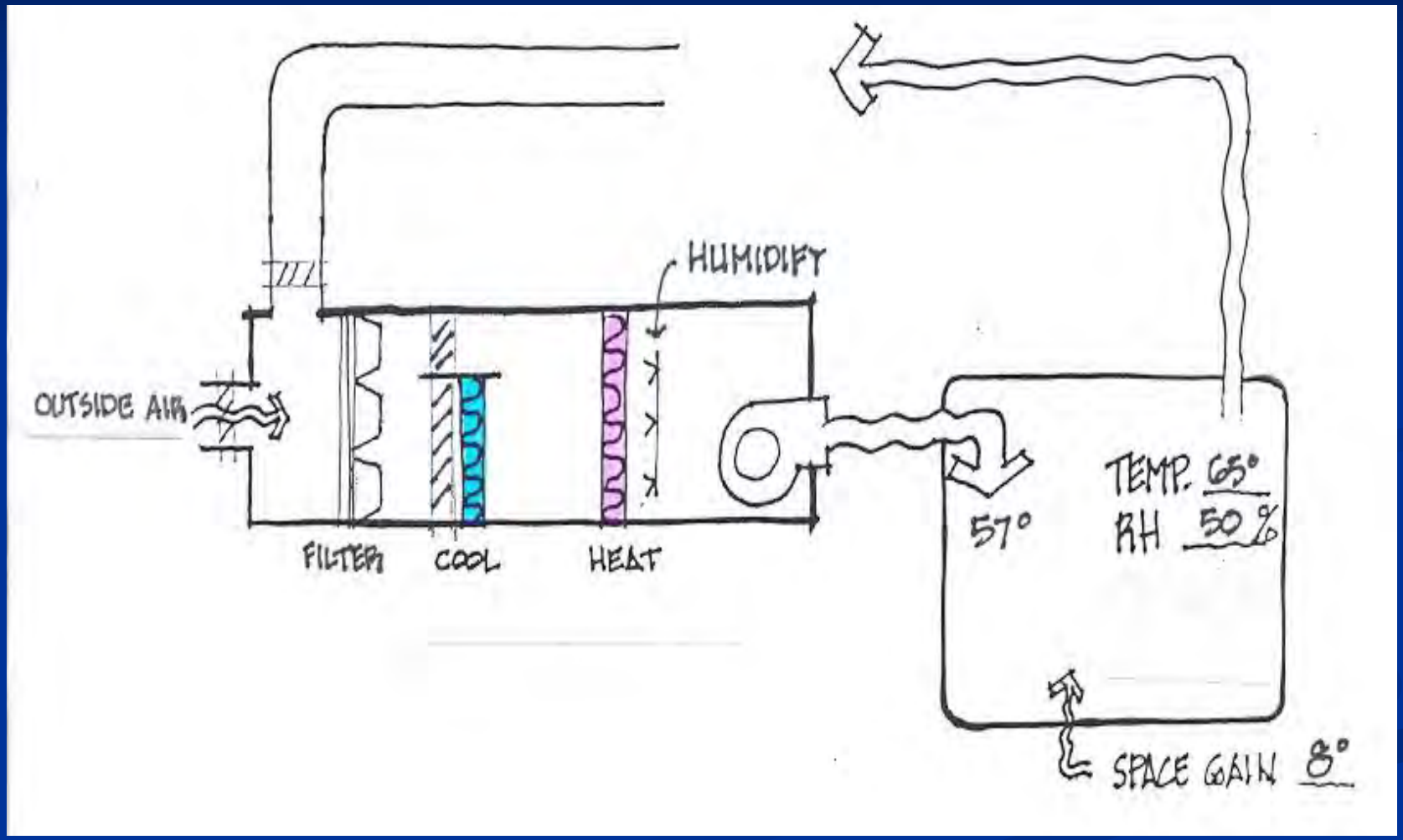
- Add data to cartoon
- Source: BMS, sensors, data loggers

Experiment

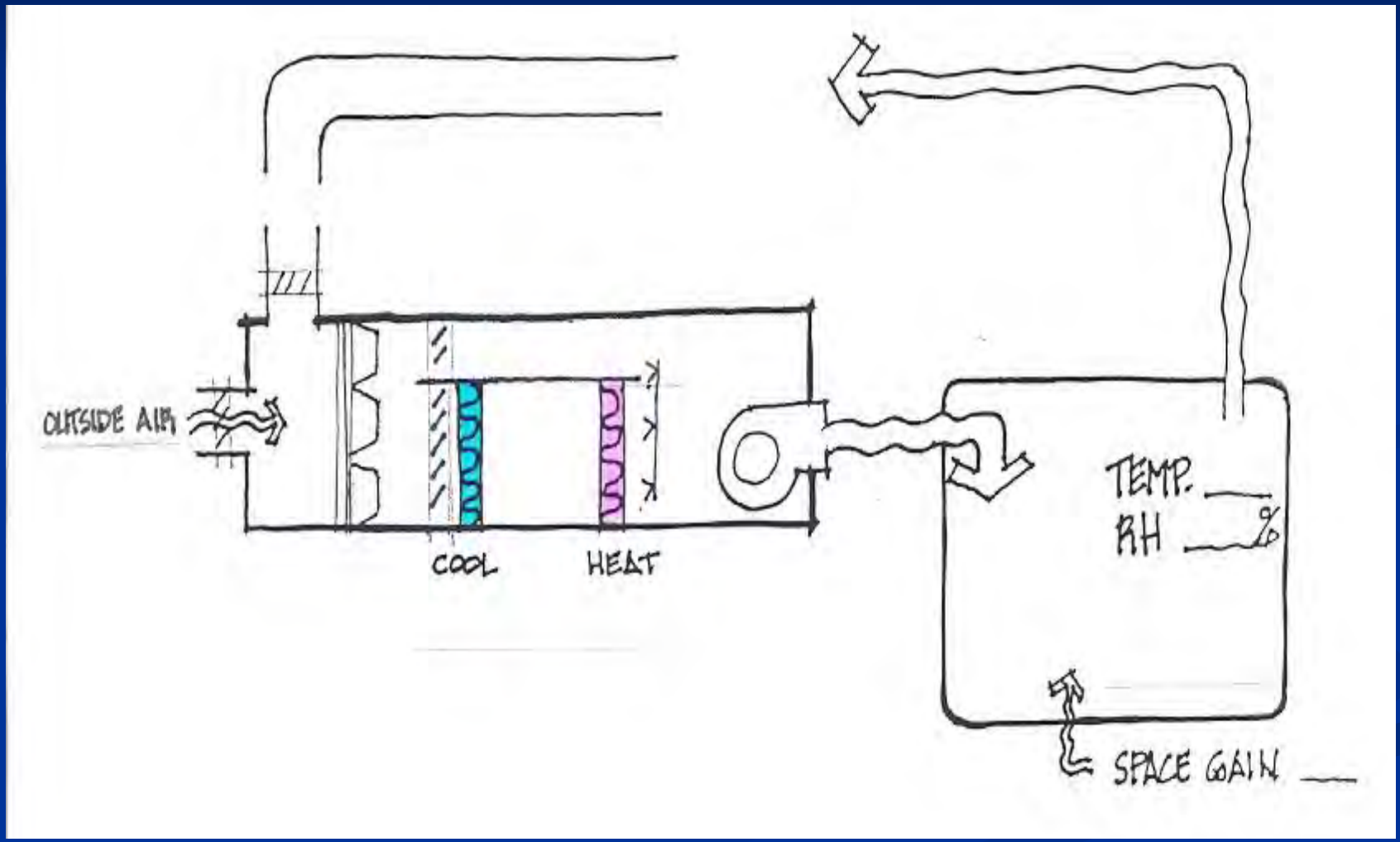
System Cartoon: Sub-Cool/Reheat



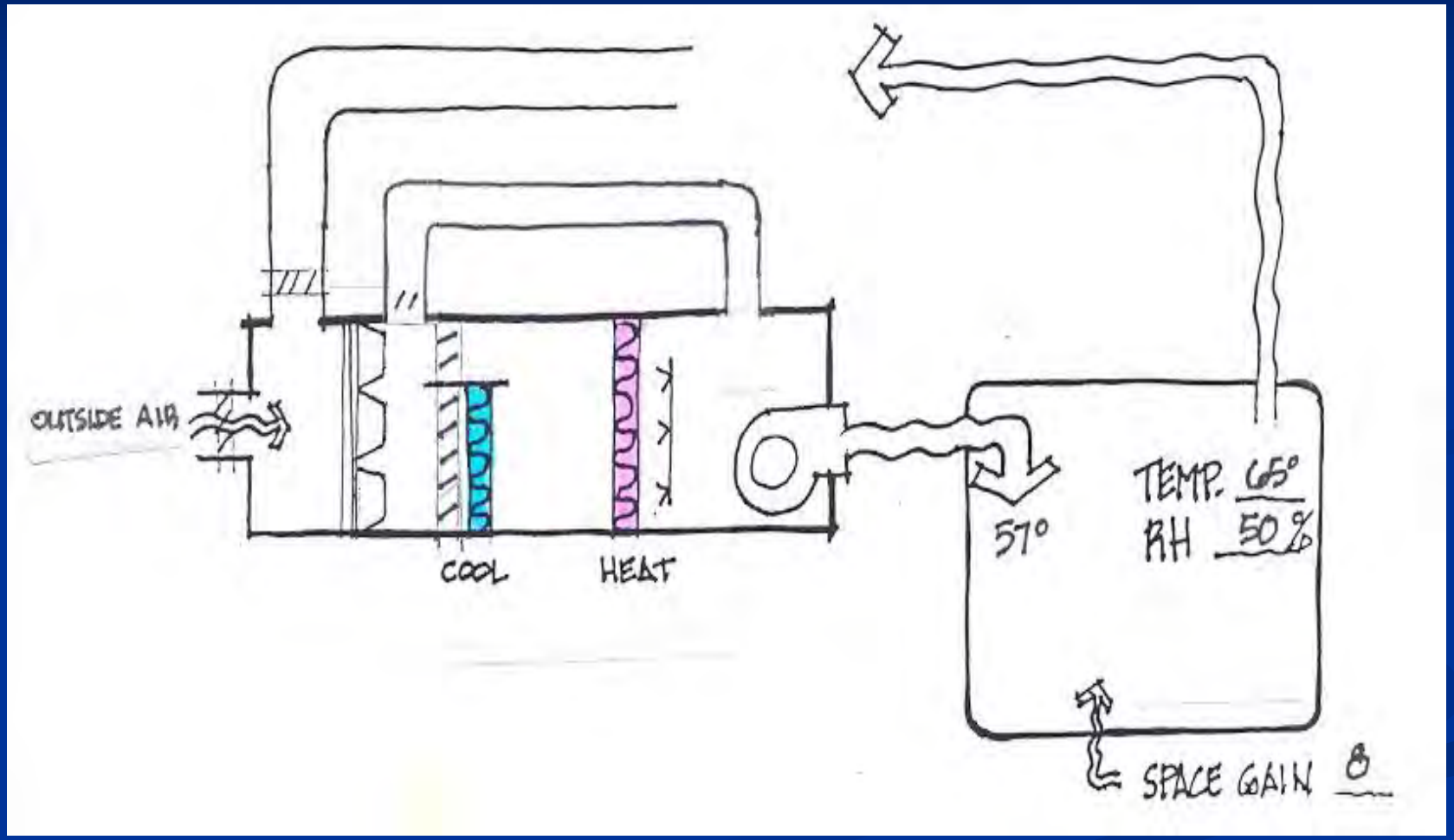
System Cartoon: Face & By-Pass



System Cartoon: Face & By-Pass



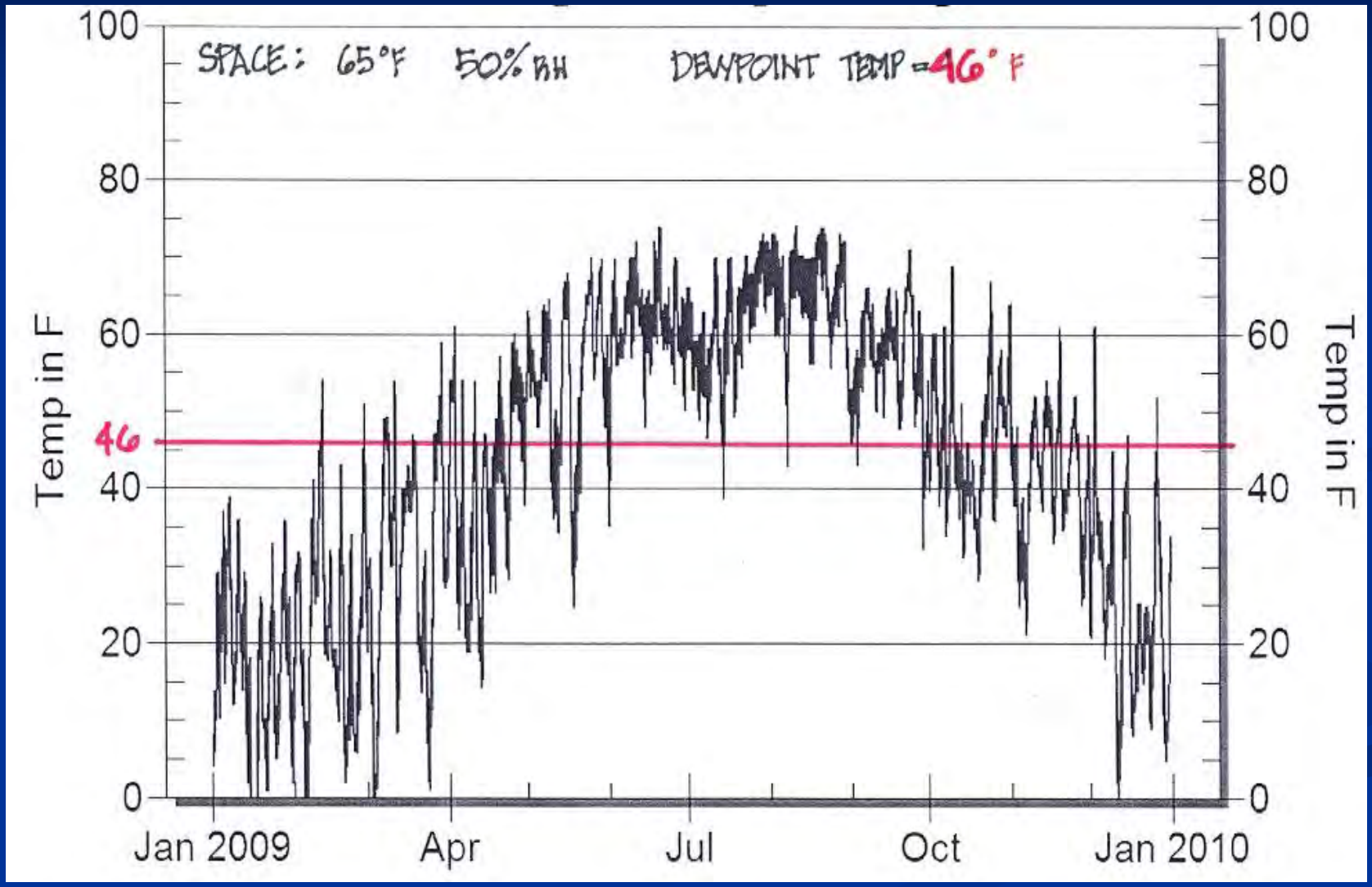
System Cartoon: Face & By-Pass



- **Understand your weather**

  Analyze annual dewpoint temperature

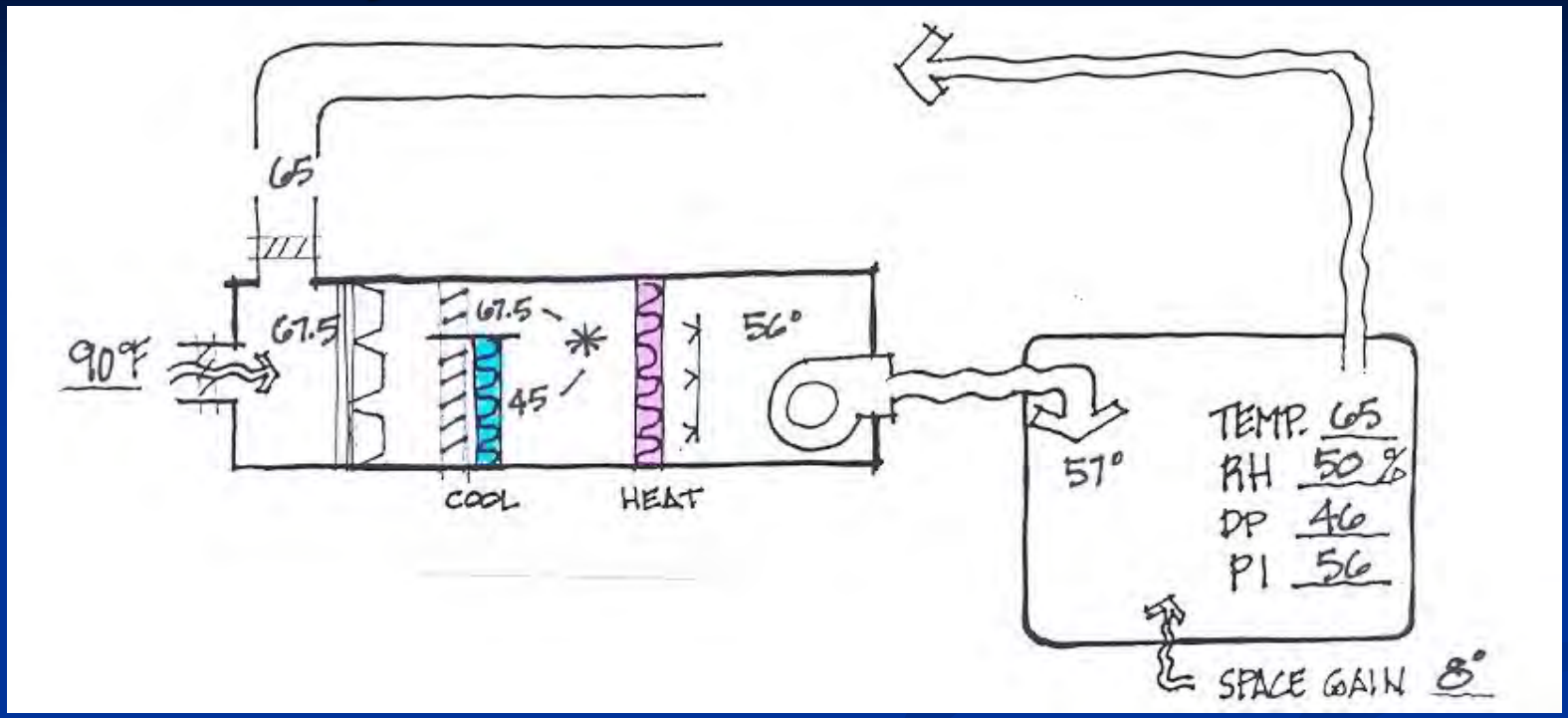
Dew Point – Washington, DC 2009

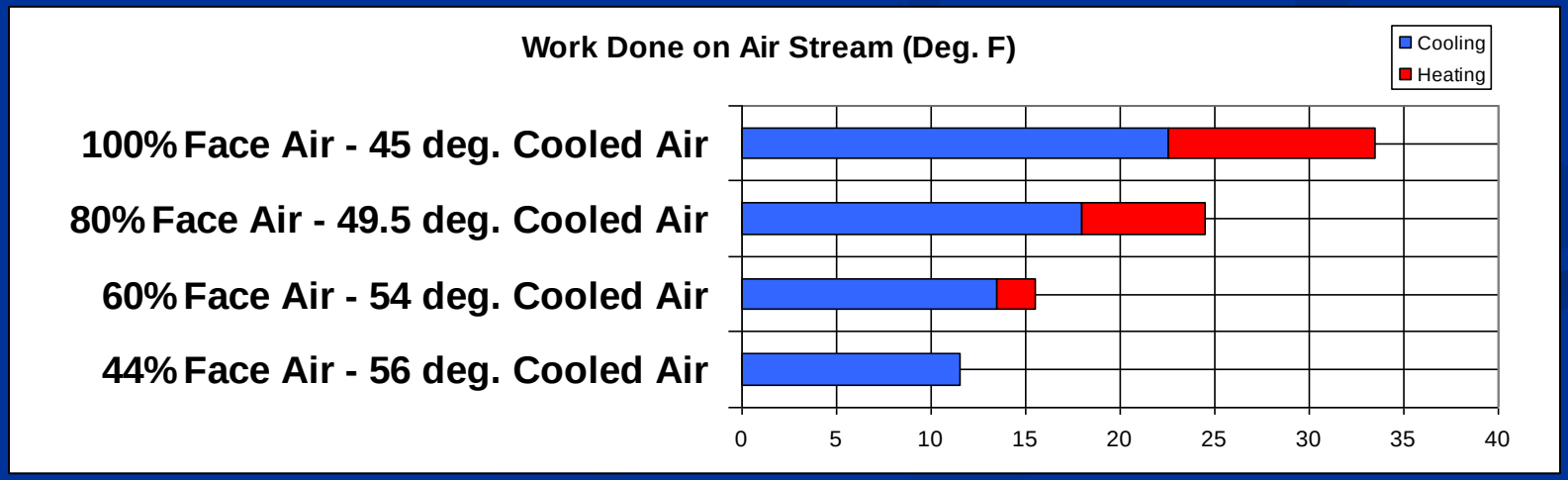


Analyze “System” Performance

- How much work is necessary?

Face & By-Pass: Summer Operation

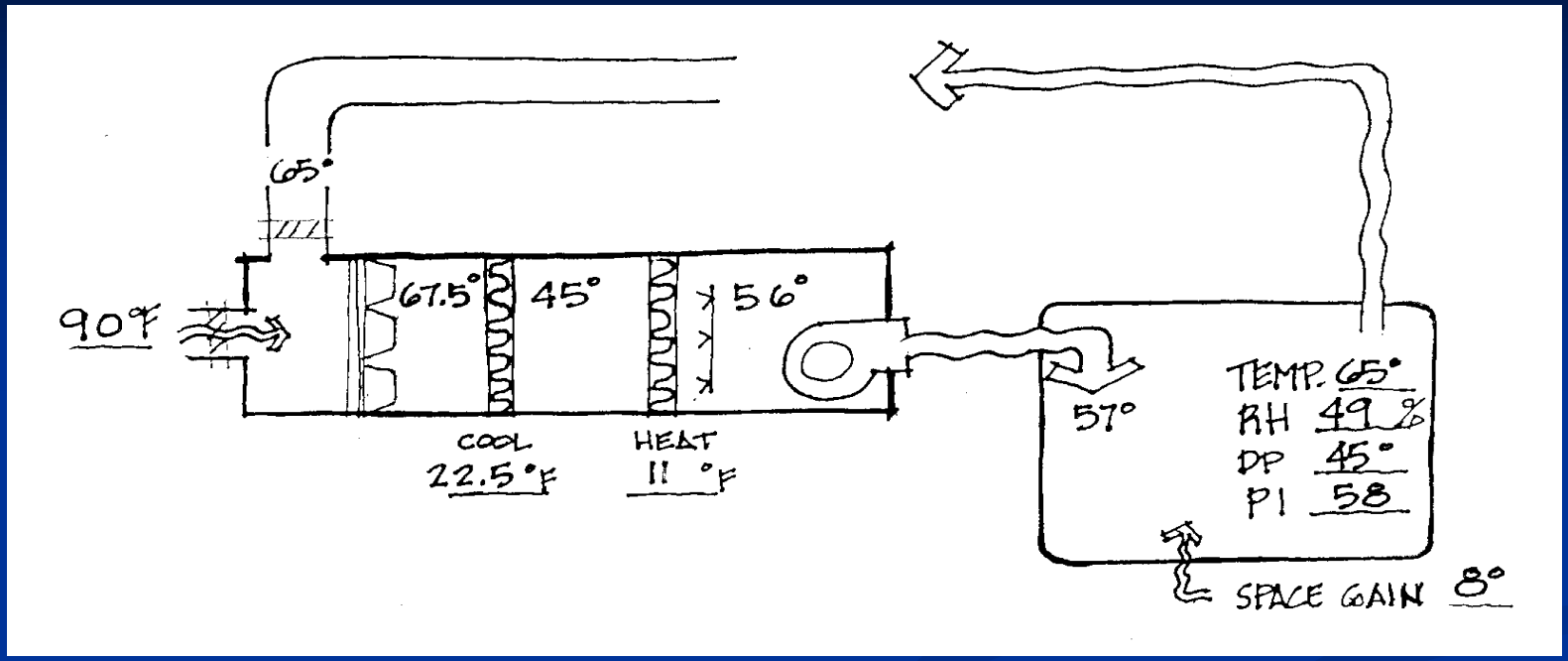


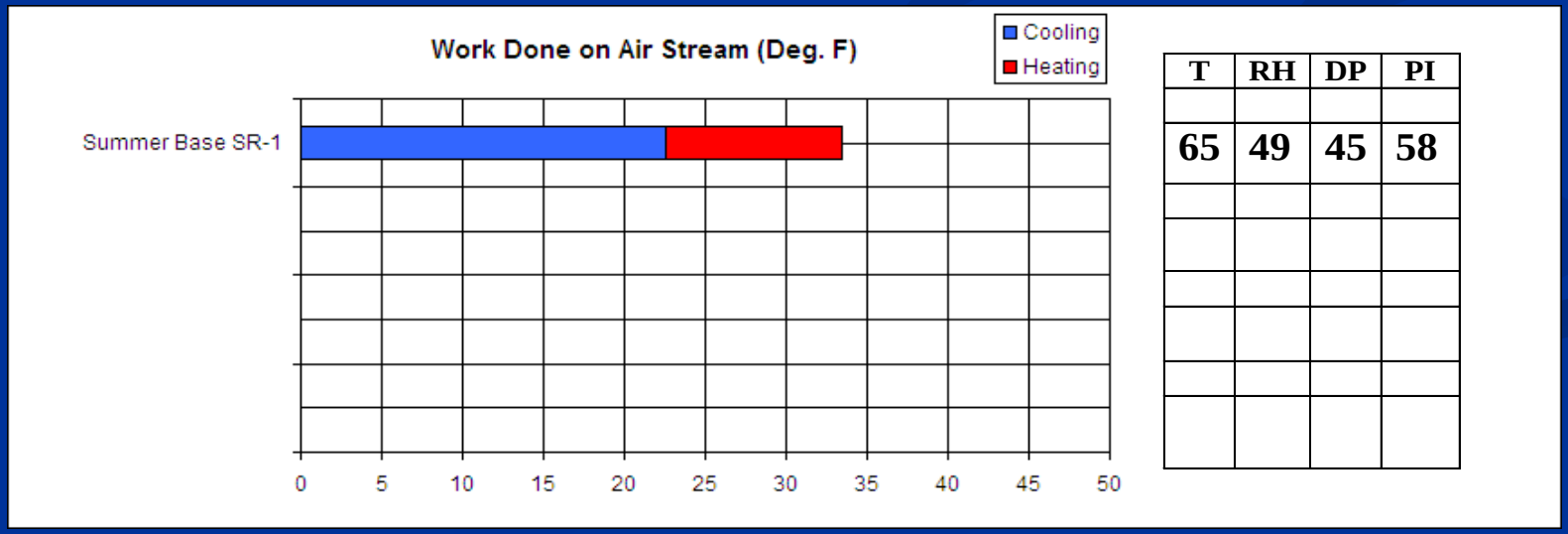


Analyze “System” Performance

- What is the optimal temperature?

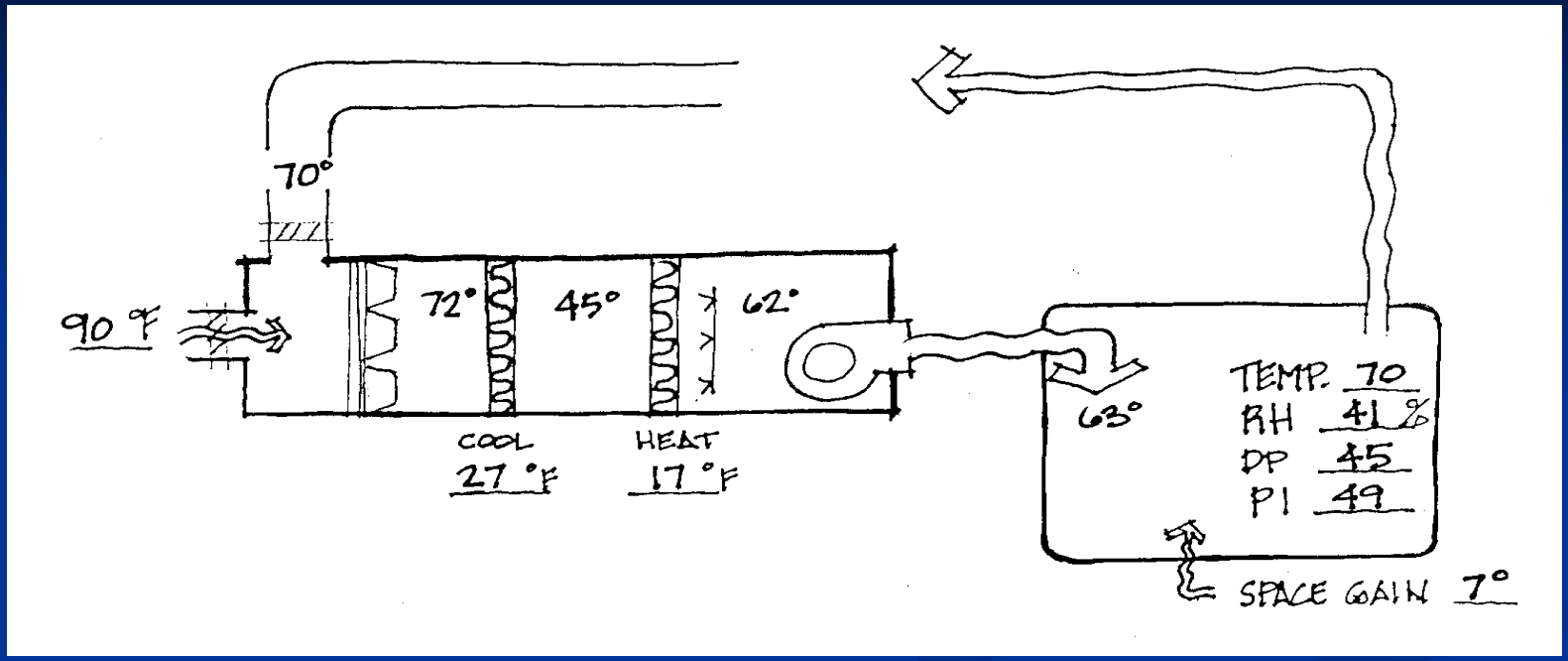
Sub-Cool & Reheat: Summer "Design" Operation

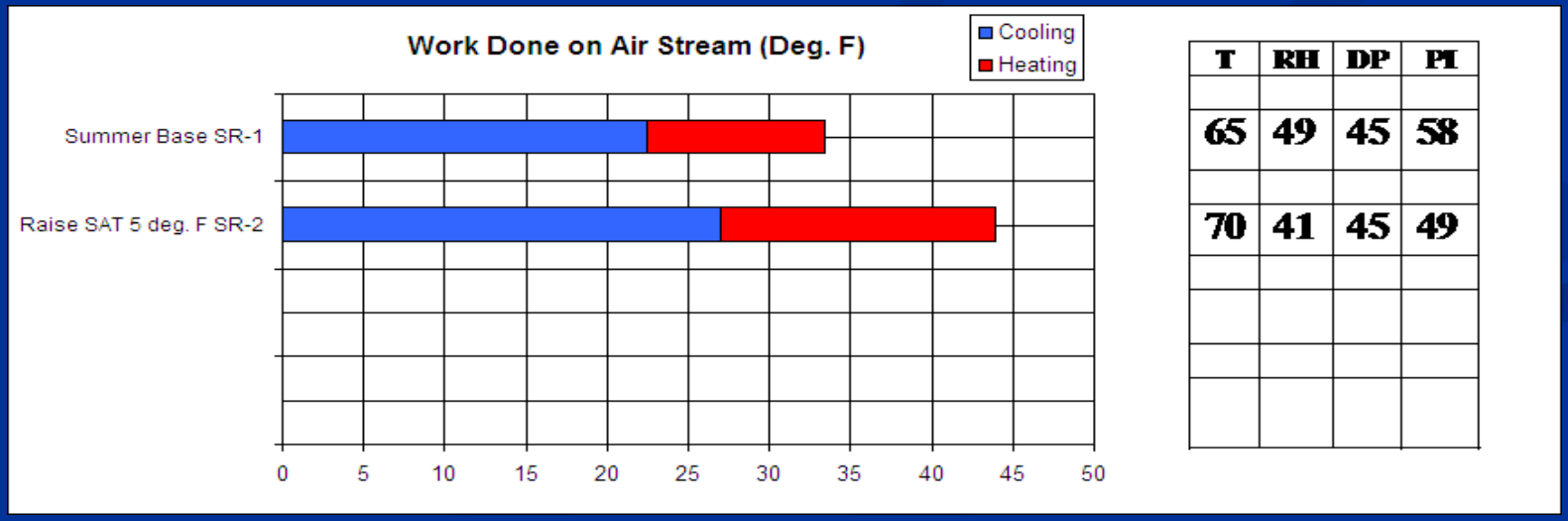




T	RH	DP	PI
65	49	45	58

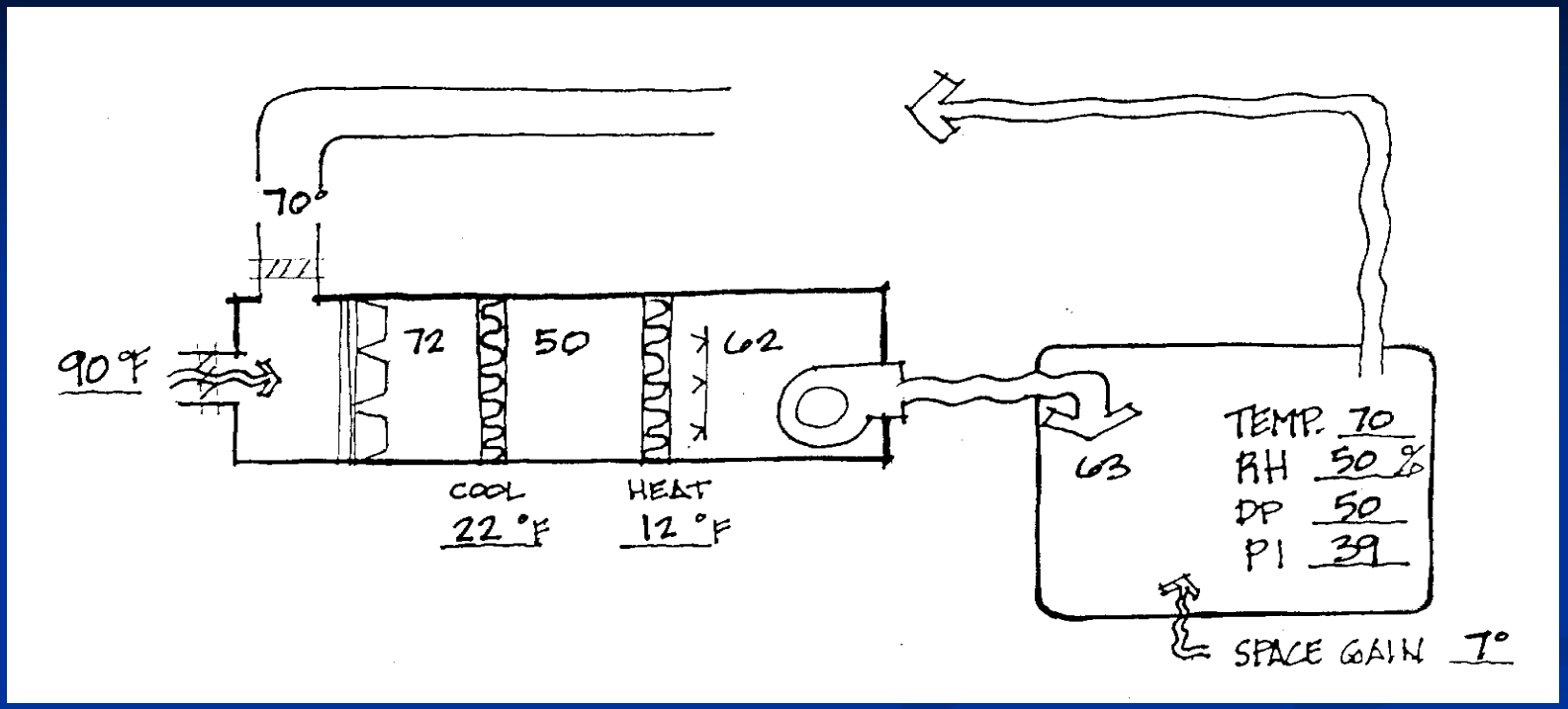
Sub-Cool & Reheat: Summer Raised Space Temp.

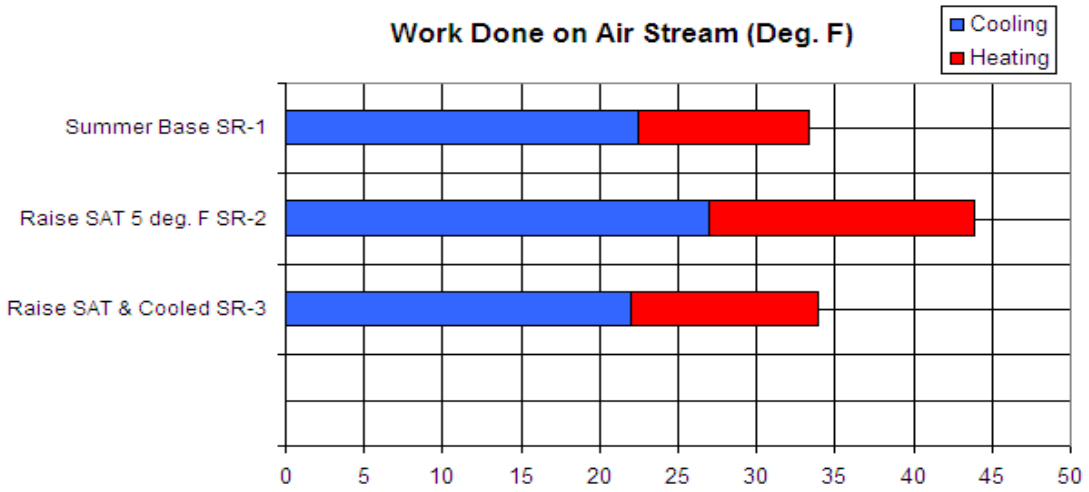




T	RH	DP	PI
65	49	45	58
70	41	45	49

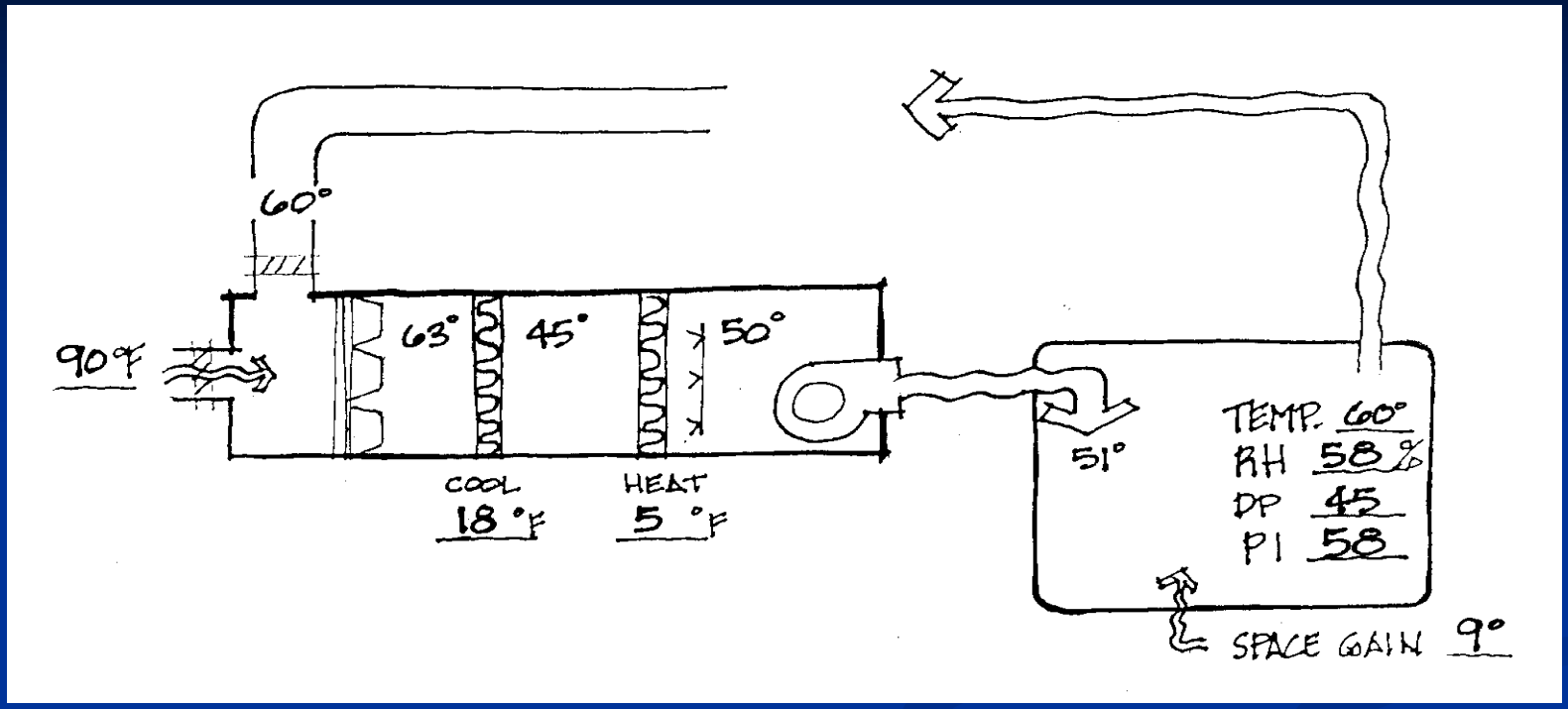
Sub-Cool & Reheat: Raised SAT & Raised Cooled Air Temp.

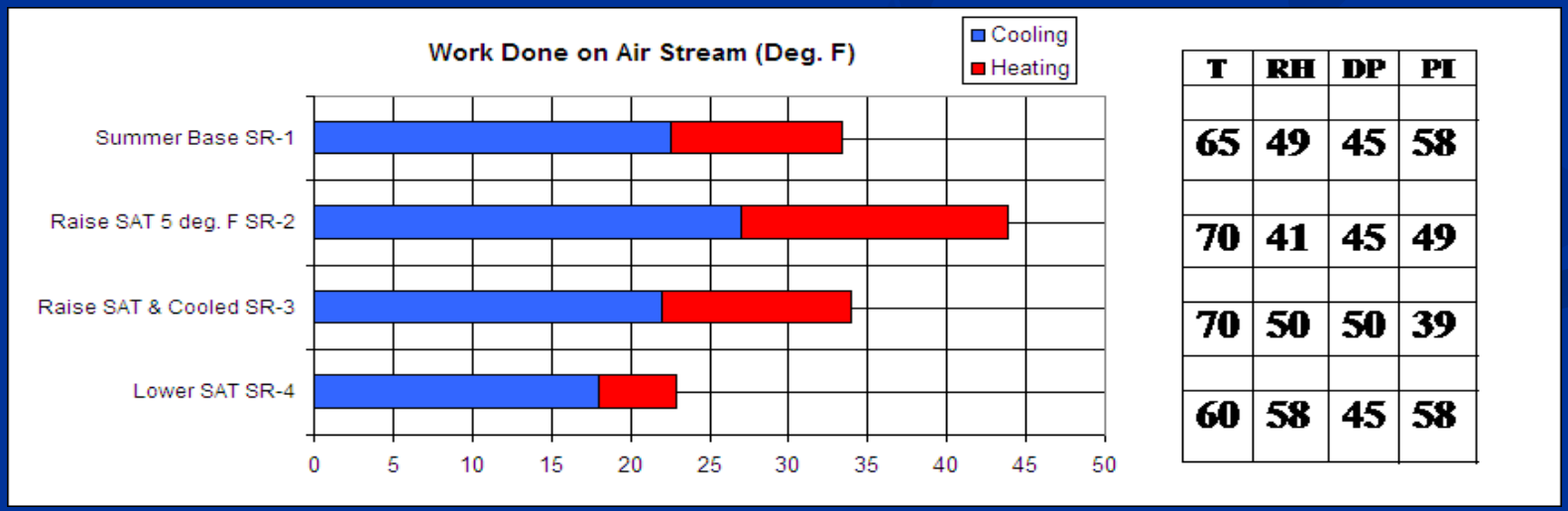




T	RH	DP	PI
65	49	45	58
70	41	45	49
70	50	50	39

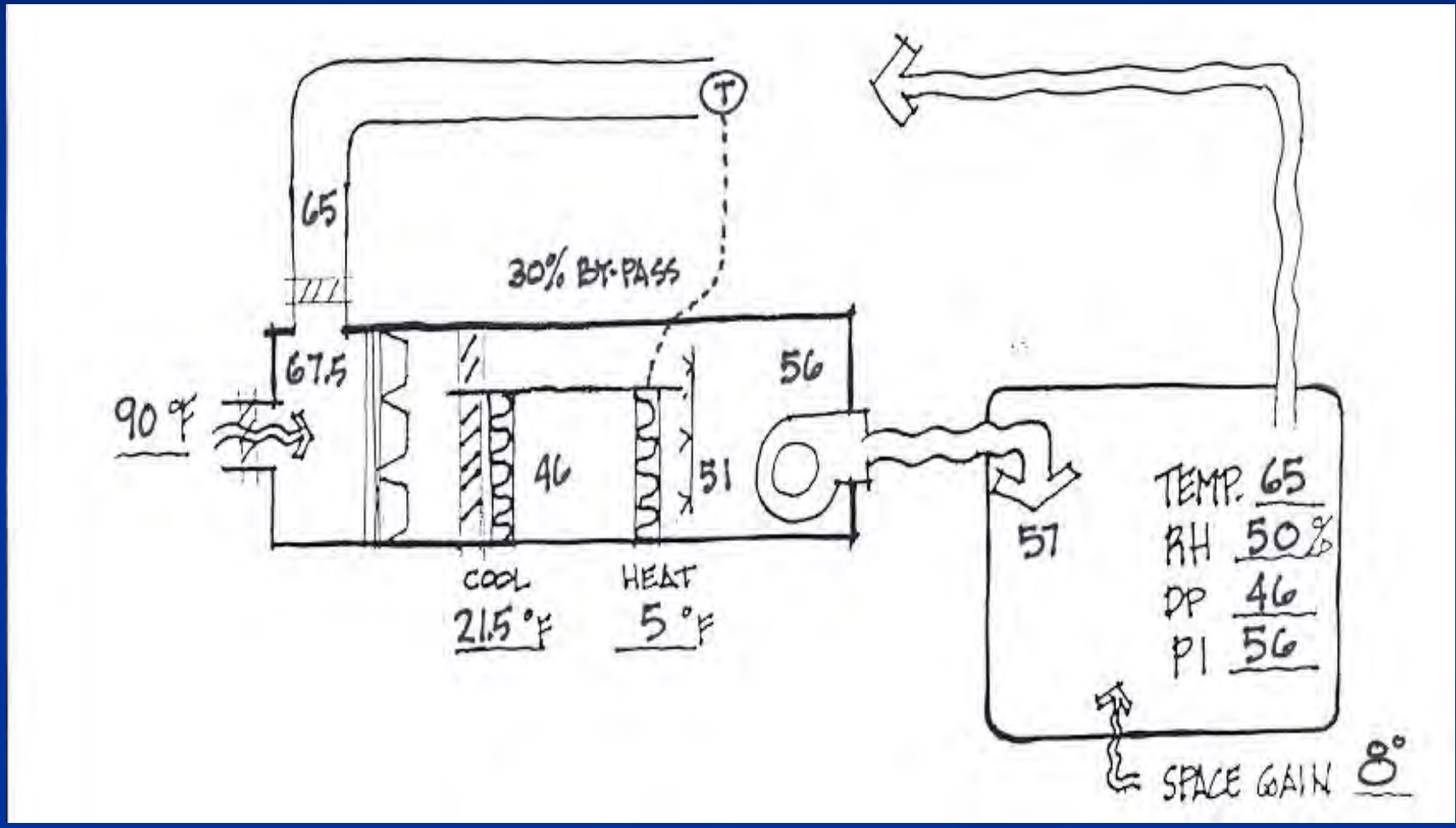
Sub-Cool & Reheat: Summer Lowered Space Temps.





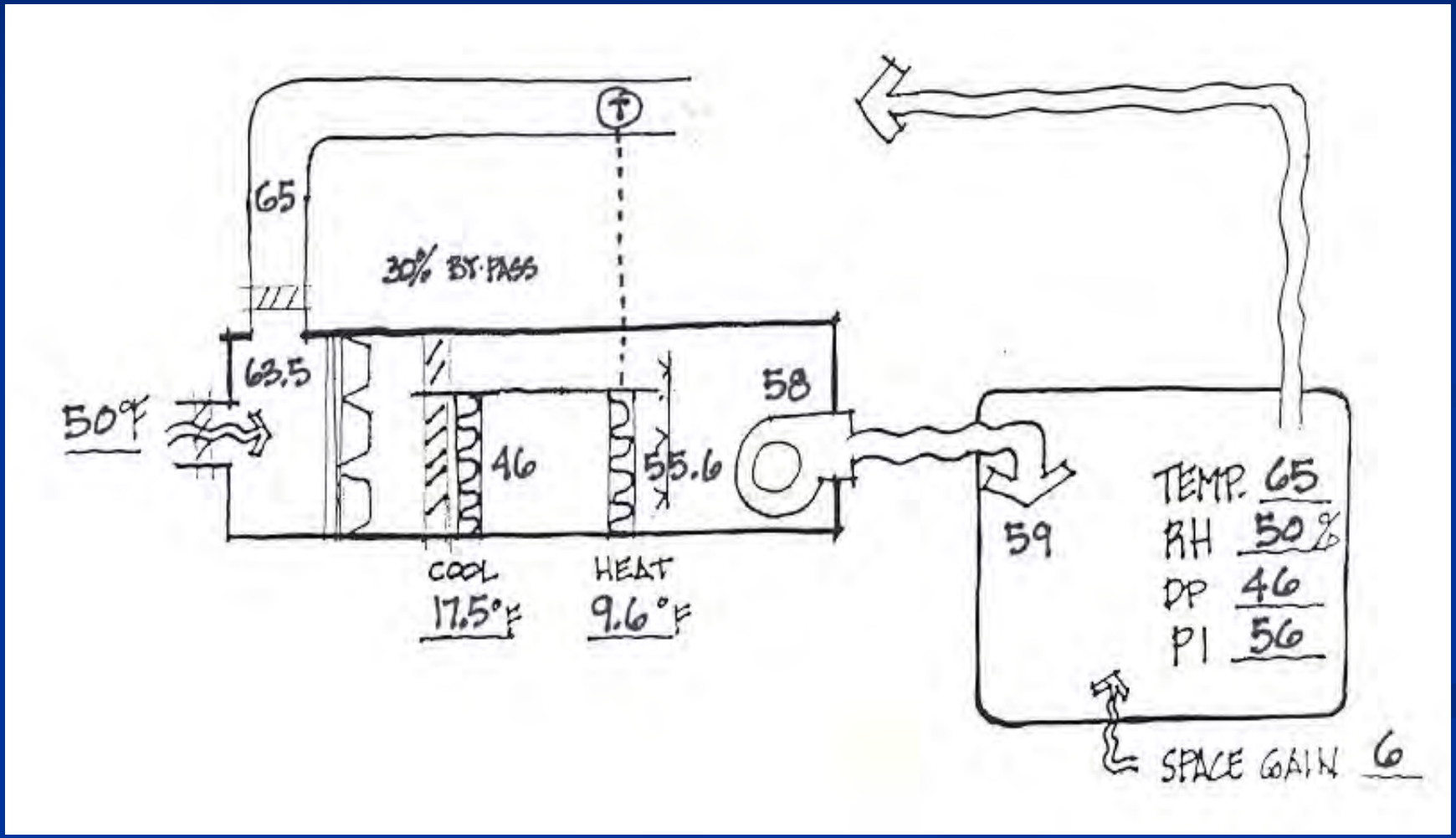
T	RH	DP	PI
65	49	45	58
70	41	45	49
70	50	50	39
60	58	45	58

Face and By-Pass System
Summer Base Operation



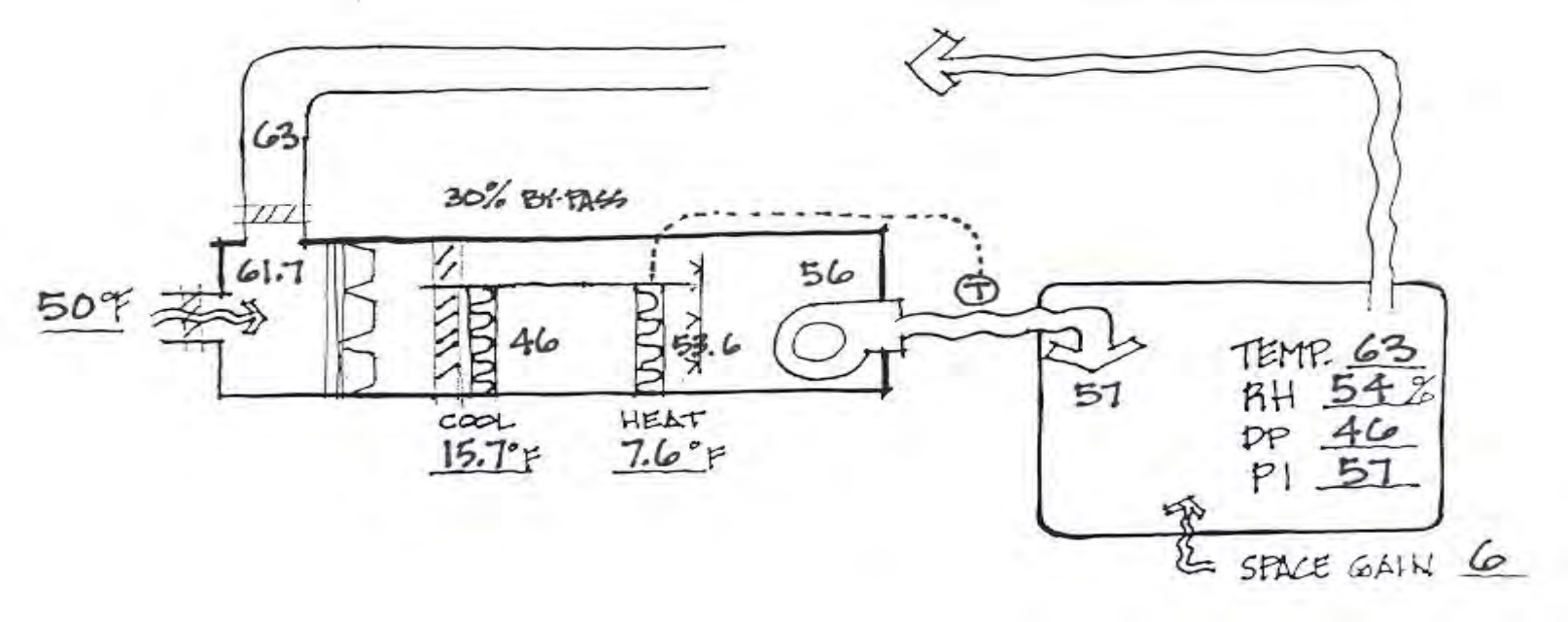
Face and By-Pass System

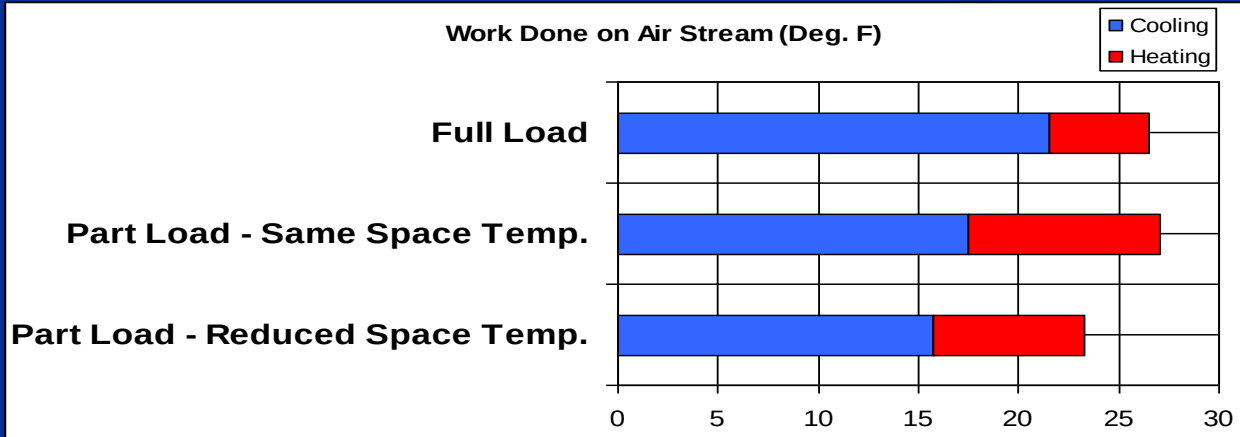
Part-Load Operation – Constant Space Temp.



Face and By-Pass System

Part-Load Operation – Reduced Space Temp.



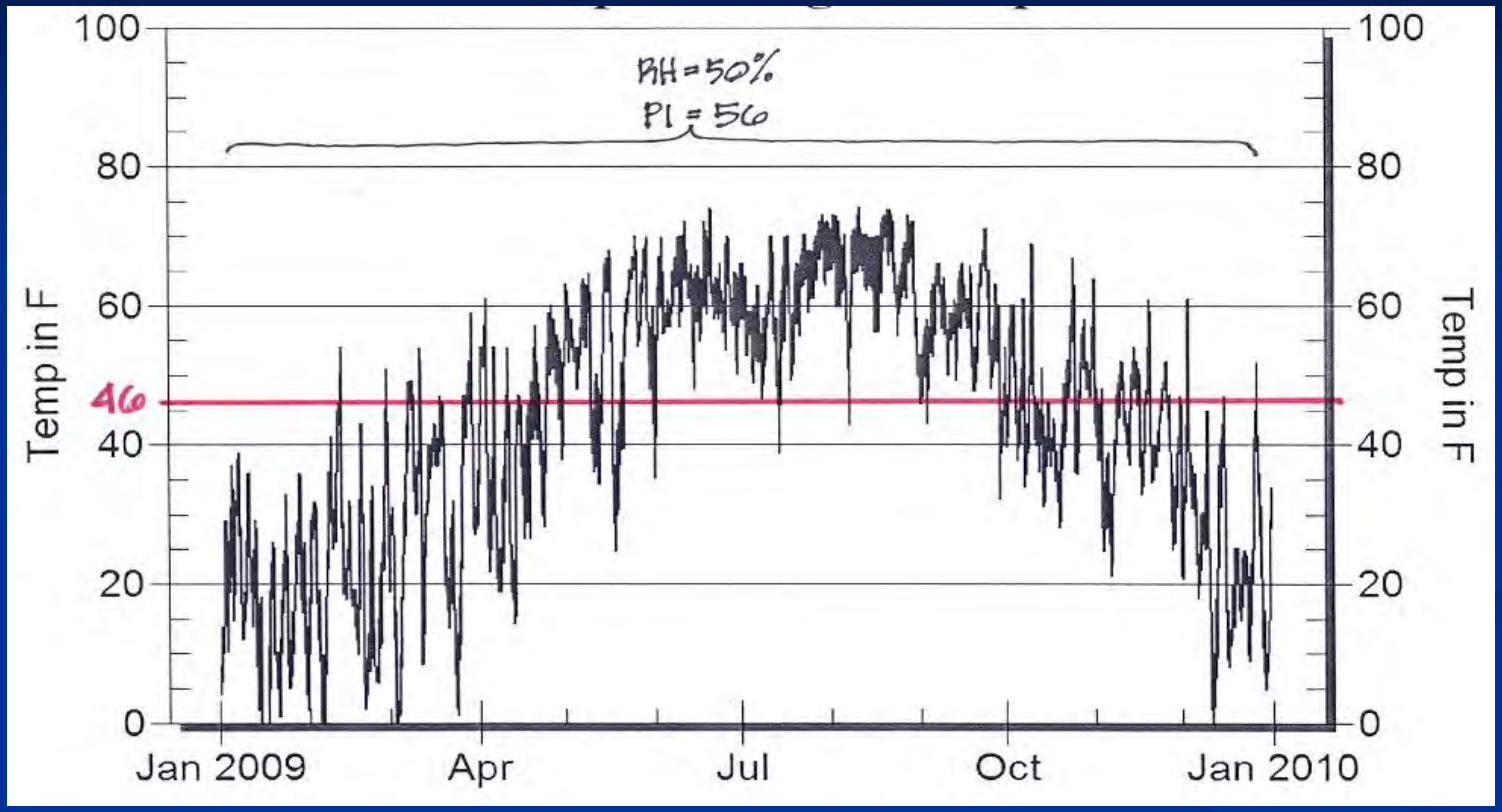


T	RH	DP	PI
65	50	46	56
65	50	46	56
63	54	46	57

Analyze “System” Performance

- What is the optimal RH?

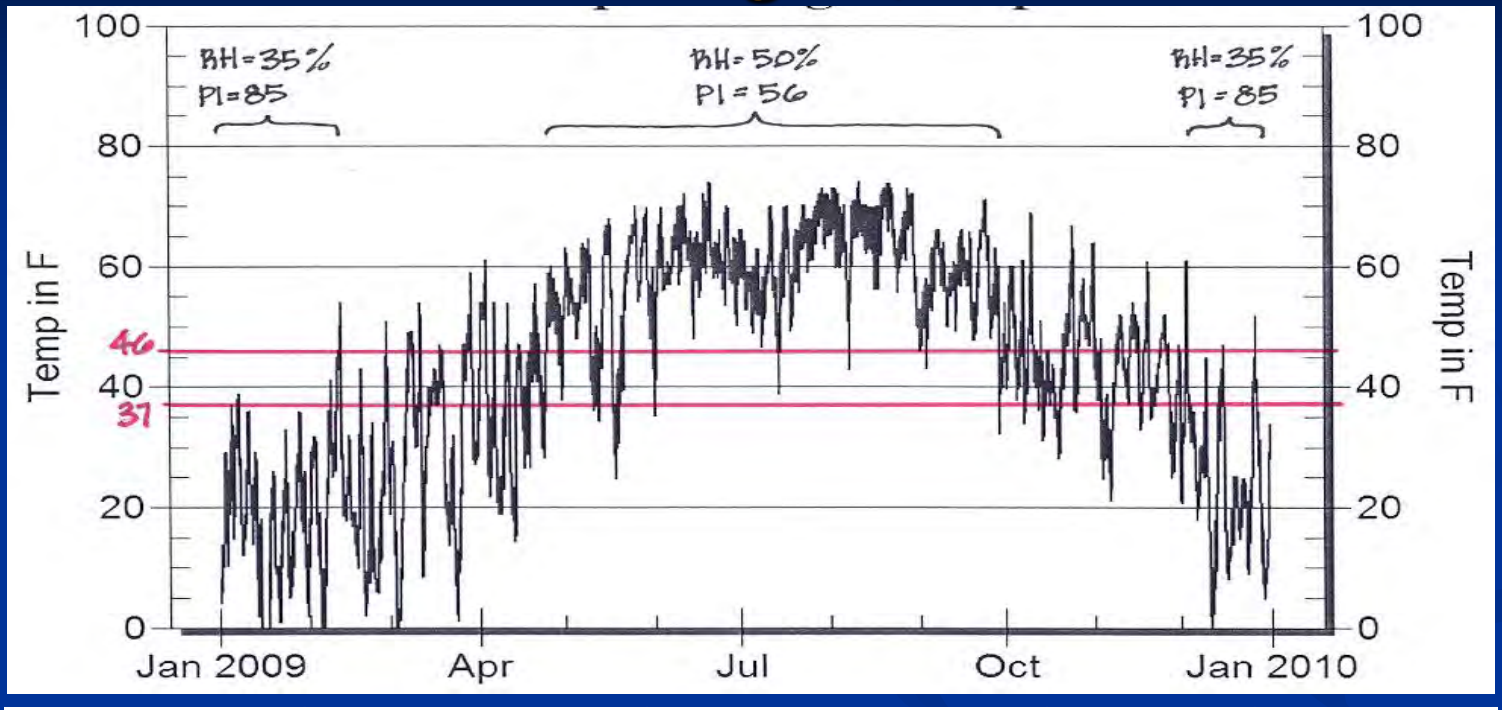
Sub-Cool/Reheat: Fixed RH
Washington, DC



Space Temp Deg F	Space RH	% of Time @ RH	PI	TWPI
65	50%	100%	56	56

Sub-Cool/Reheat: Variable RH

Washington, DC



Space Temp Deg F	Space RH	% of Time @ RH	PI	TWPI
65	50%	100%	56	56
65	50%	42%	56	
	35% to 50%	12%	72*	63.6
	35%	46%	85	

* PI at average dewpoint

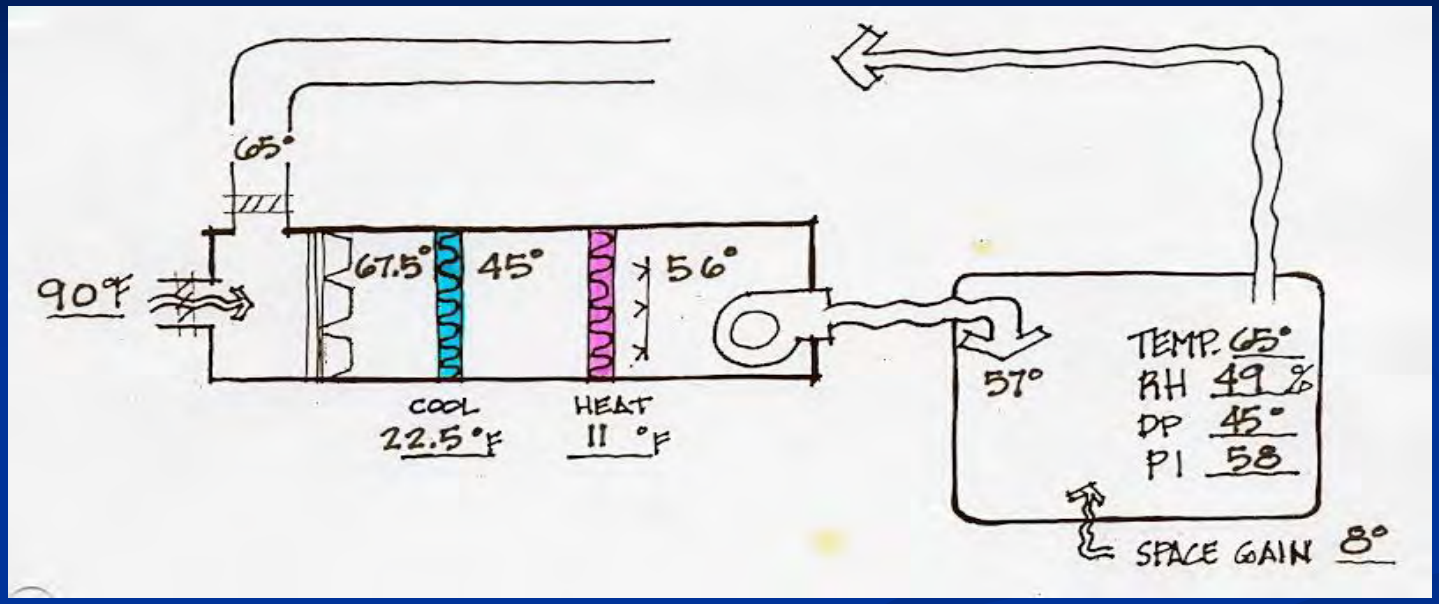
TWPI Benefit of RH Drift – Washington, D.C.

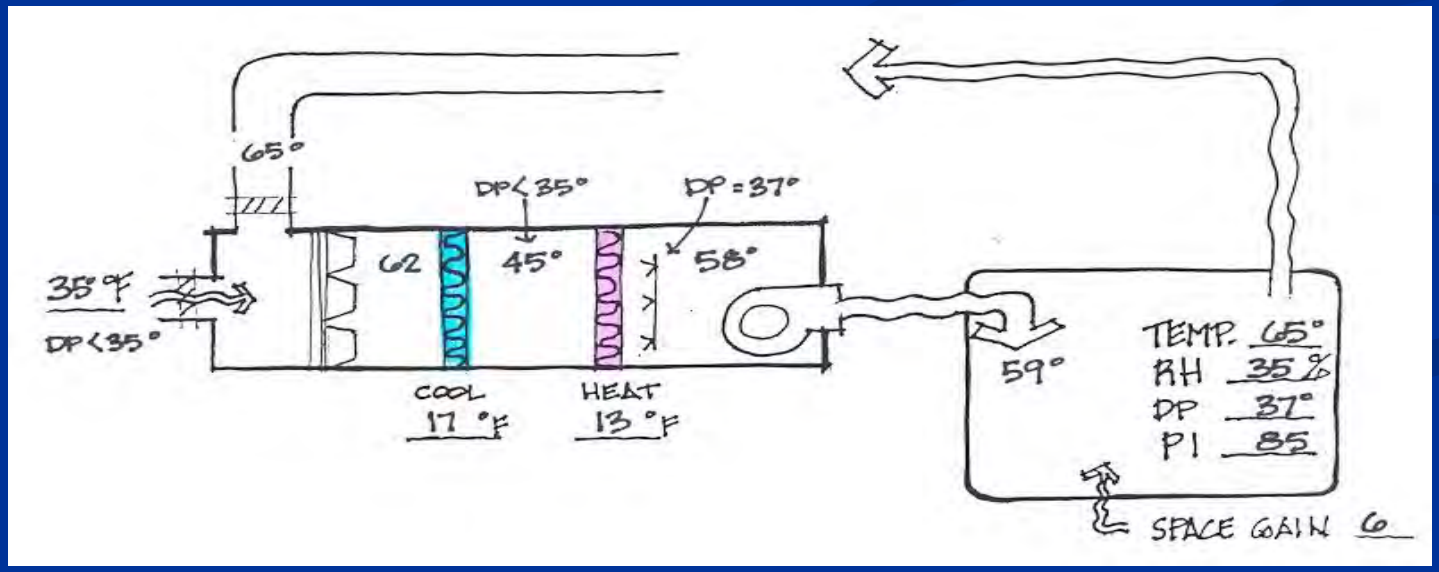
		PI				
Temp.	RH	Above High Limit	Between Limits	Below Low Limit	**TWPI**	**% Better than Base**
65	50% Flat	56			**56.0**	
"	50%-35%	56	72	85	**63.6**	**13.6%**
"	50%-30%	56	78	98	**76.6**	**36.7%**
"	60%-30%	43	66	98	**62.6**	**12.0%**

Analyze "System" Performance

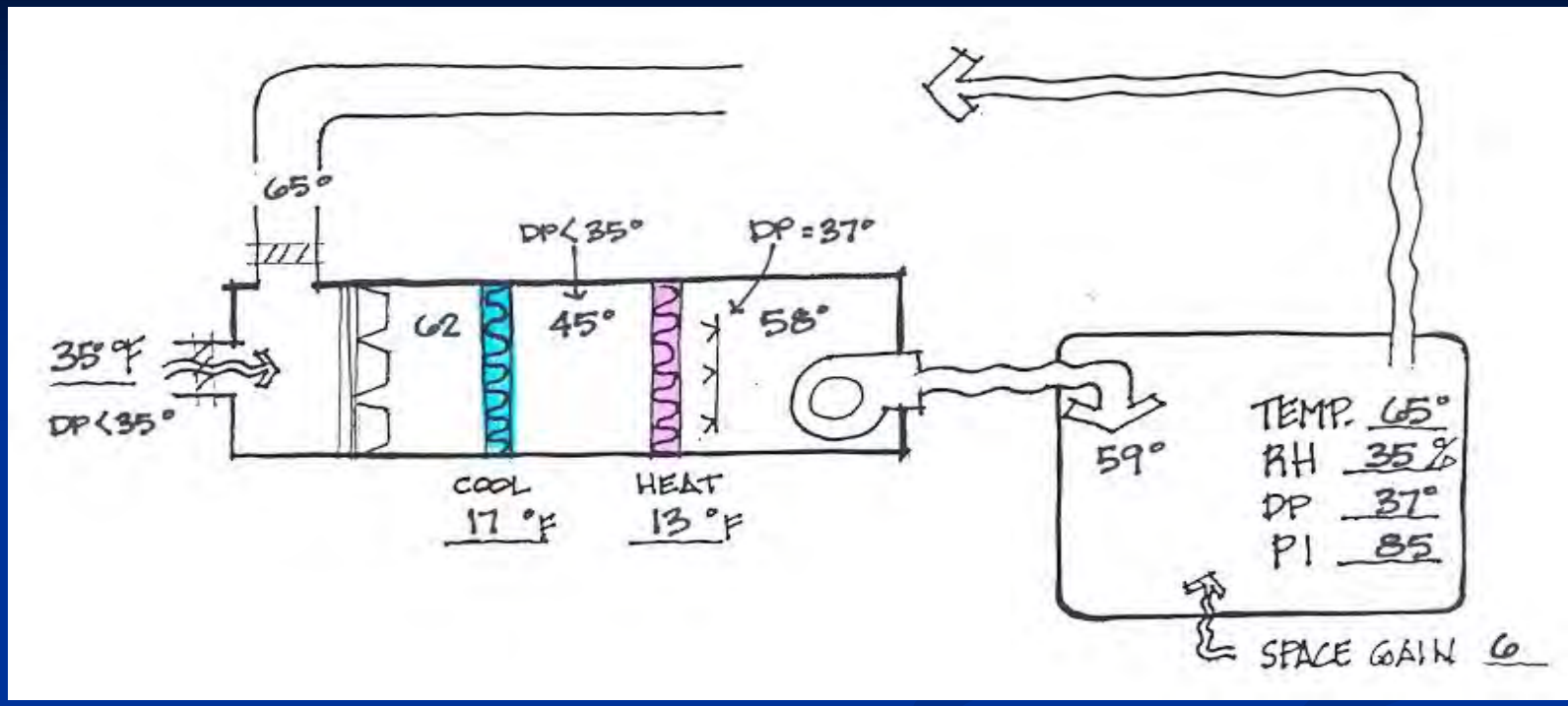
- **What is optimal cooled air temperature:**
  - Summer?
  - Winter?

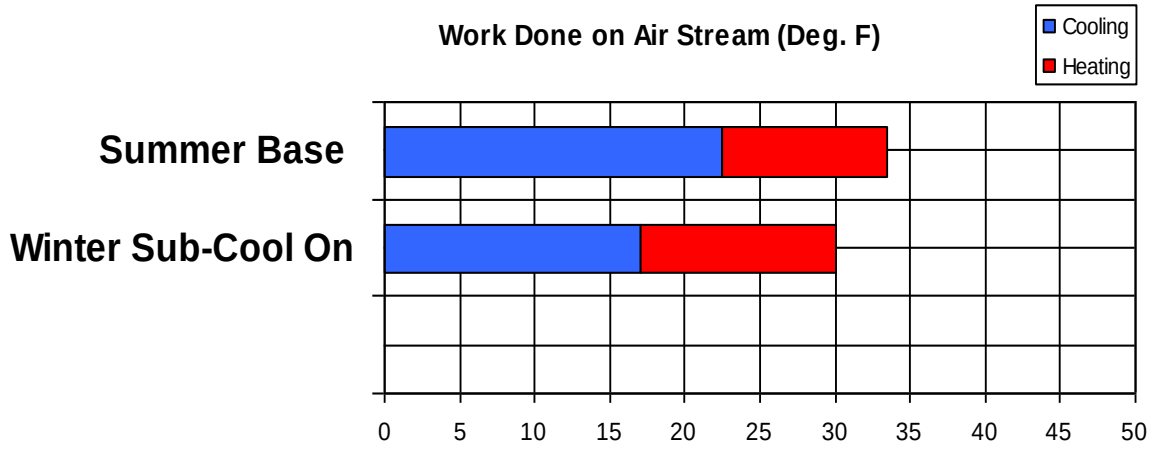
Optimal Cooled Air Temperature:
Summer vs. Winter





Sub-Cool/Reheat: Winter Sub-cool ON

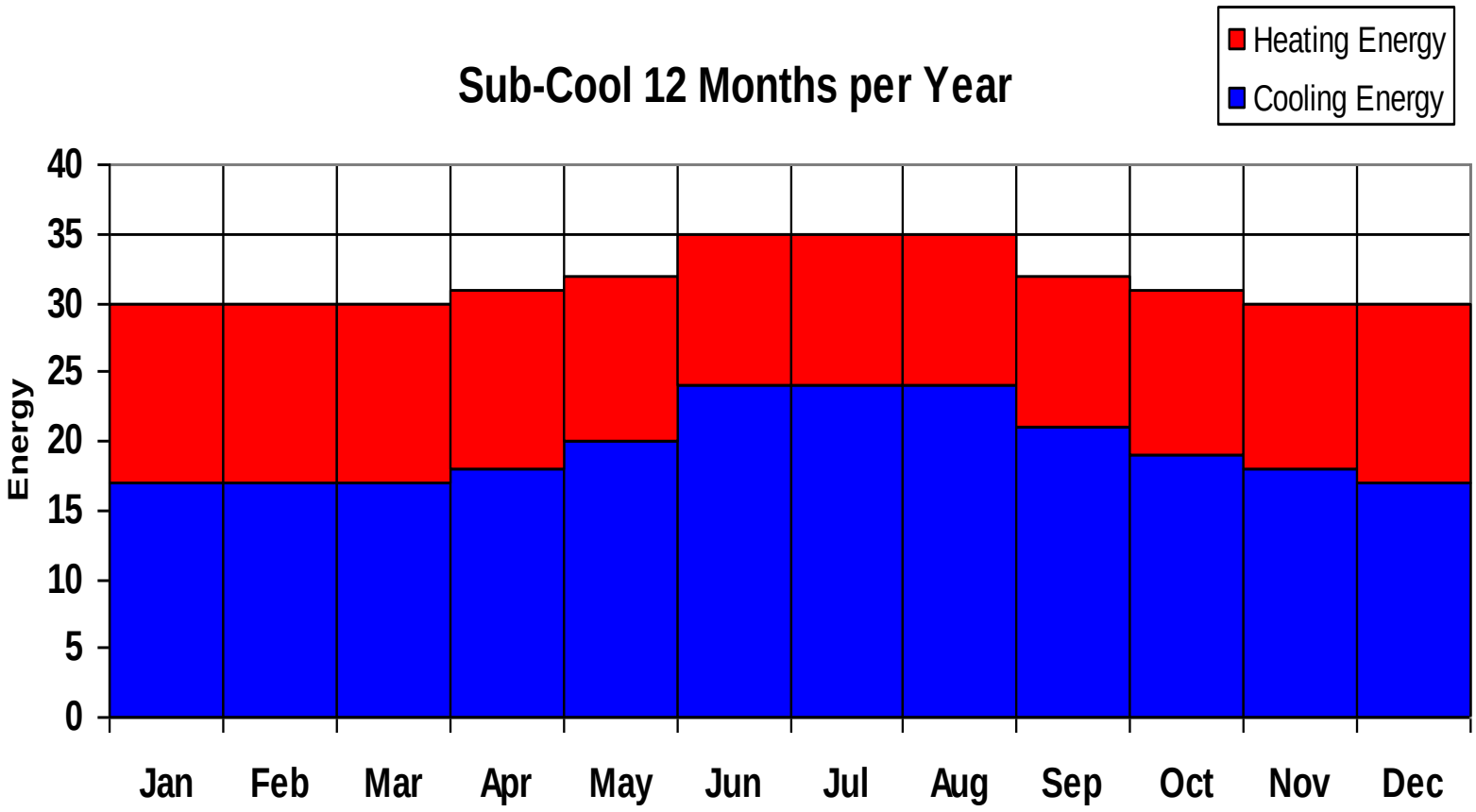




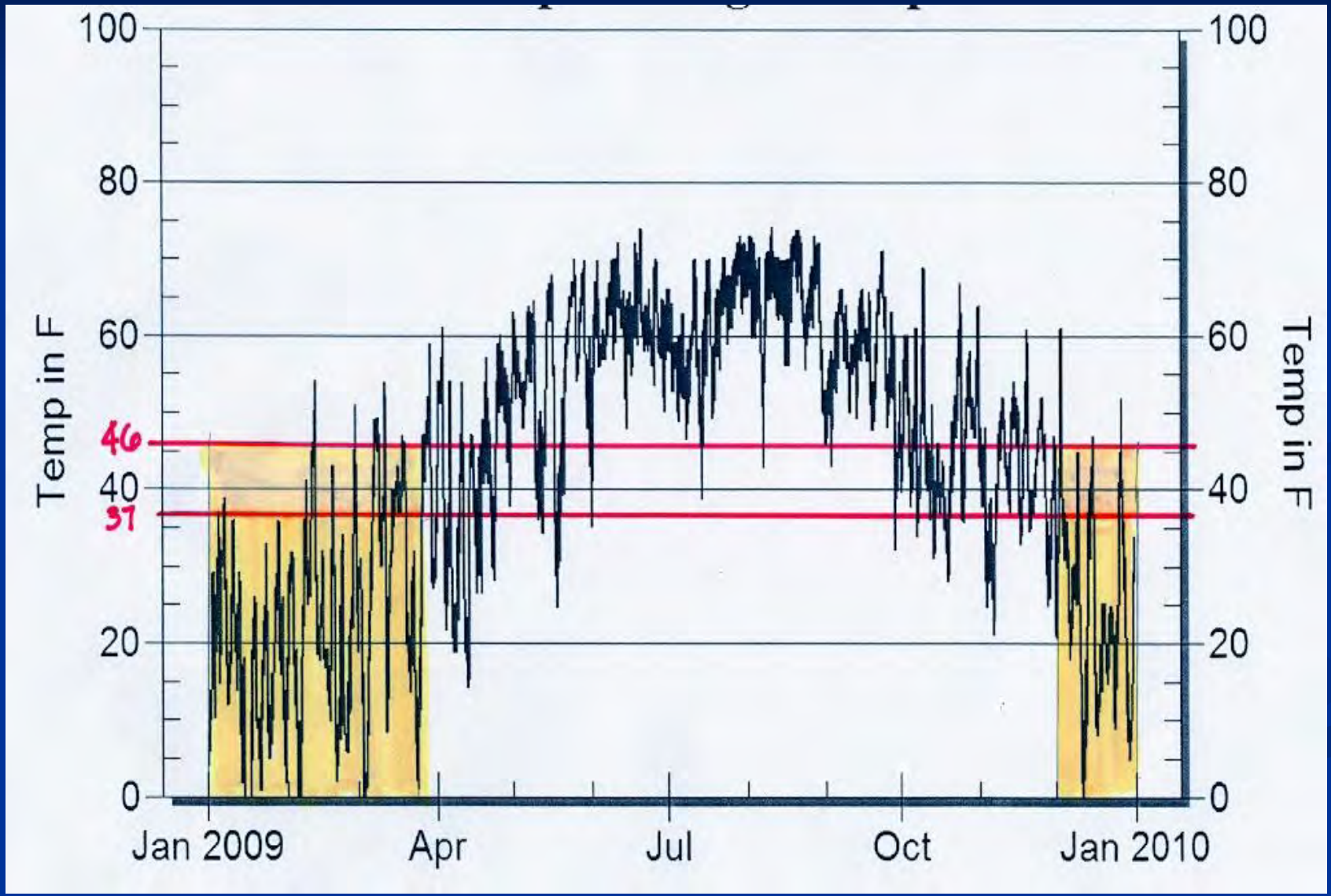
T	RH	DP	PI
65	49	45	58
65	35	37	85

Sub-Cool/Reheat

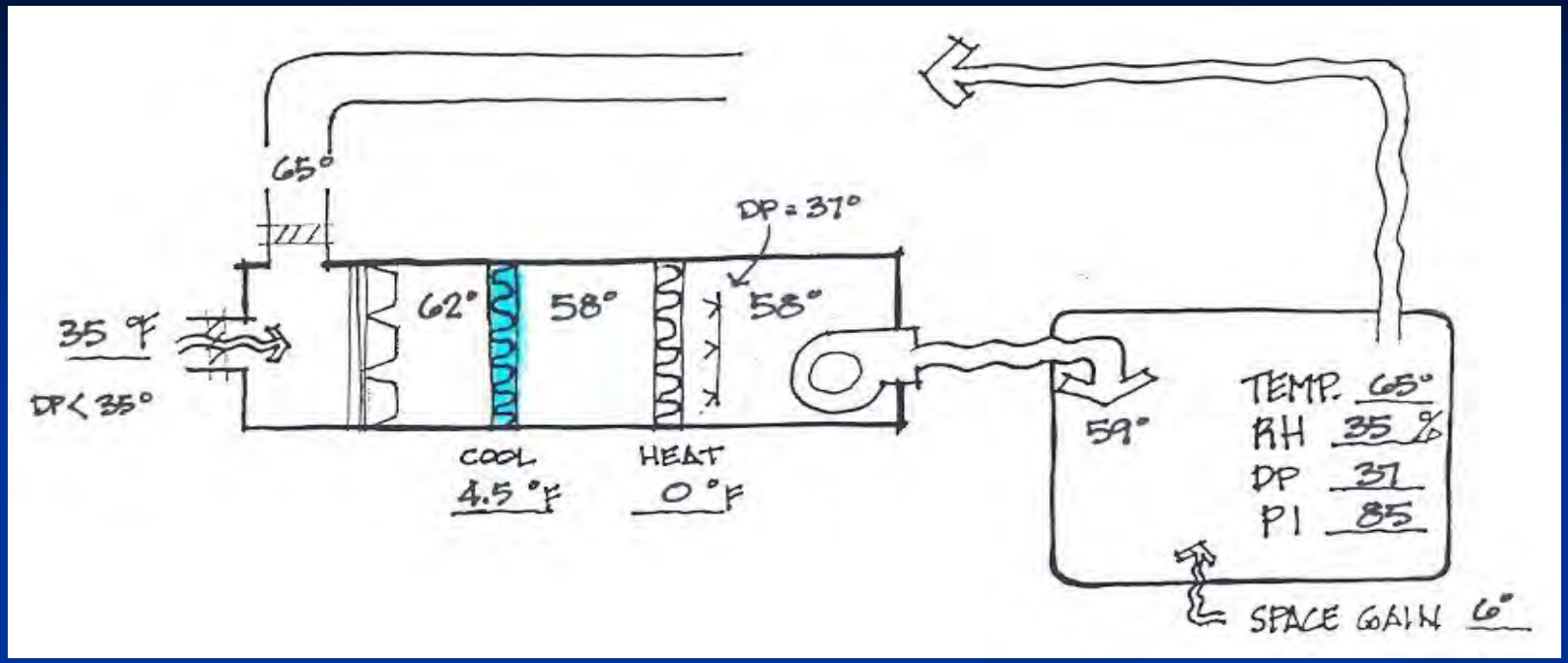
65 deg. Space, 50% RH Summer, 35% RH Winter

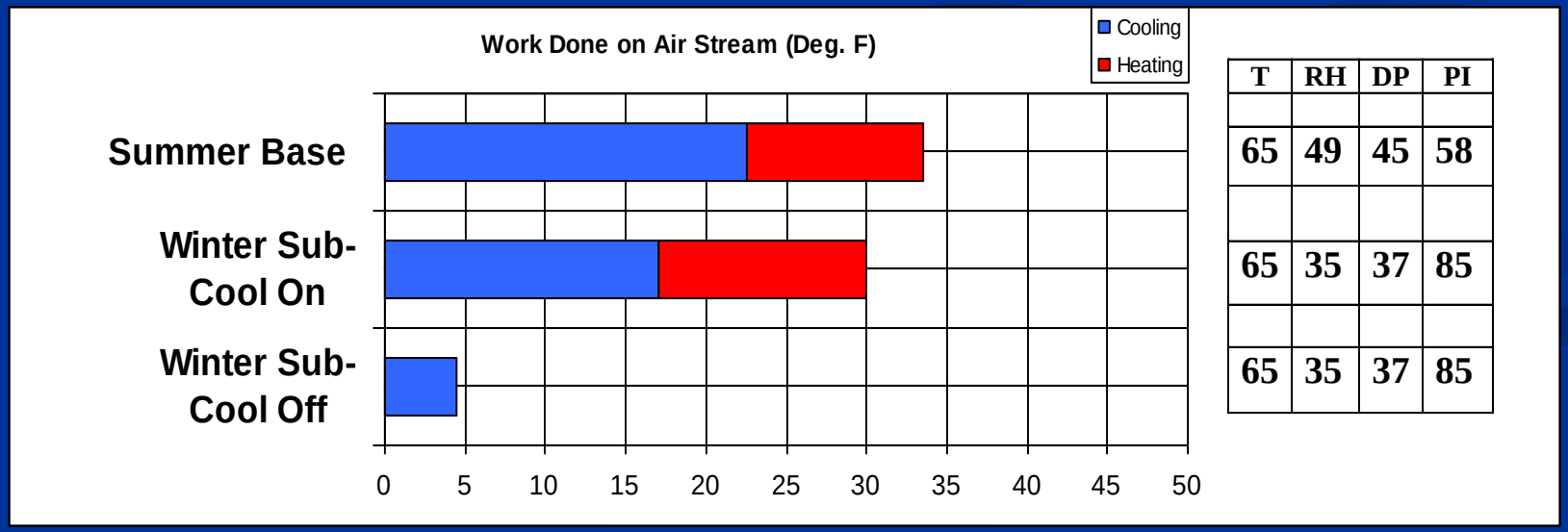


When Sub-Cooling is Unnecessary



Sub-Cool/Reheat: Winter Sub-cool OFF

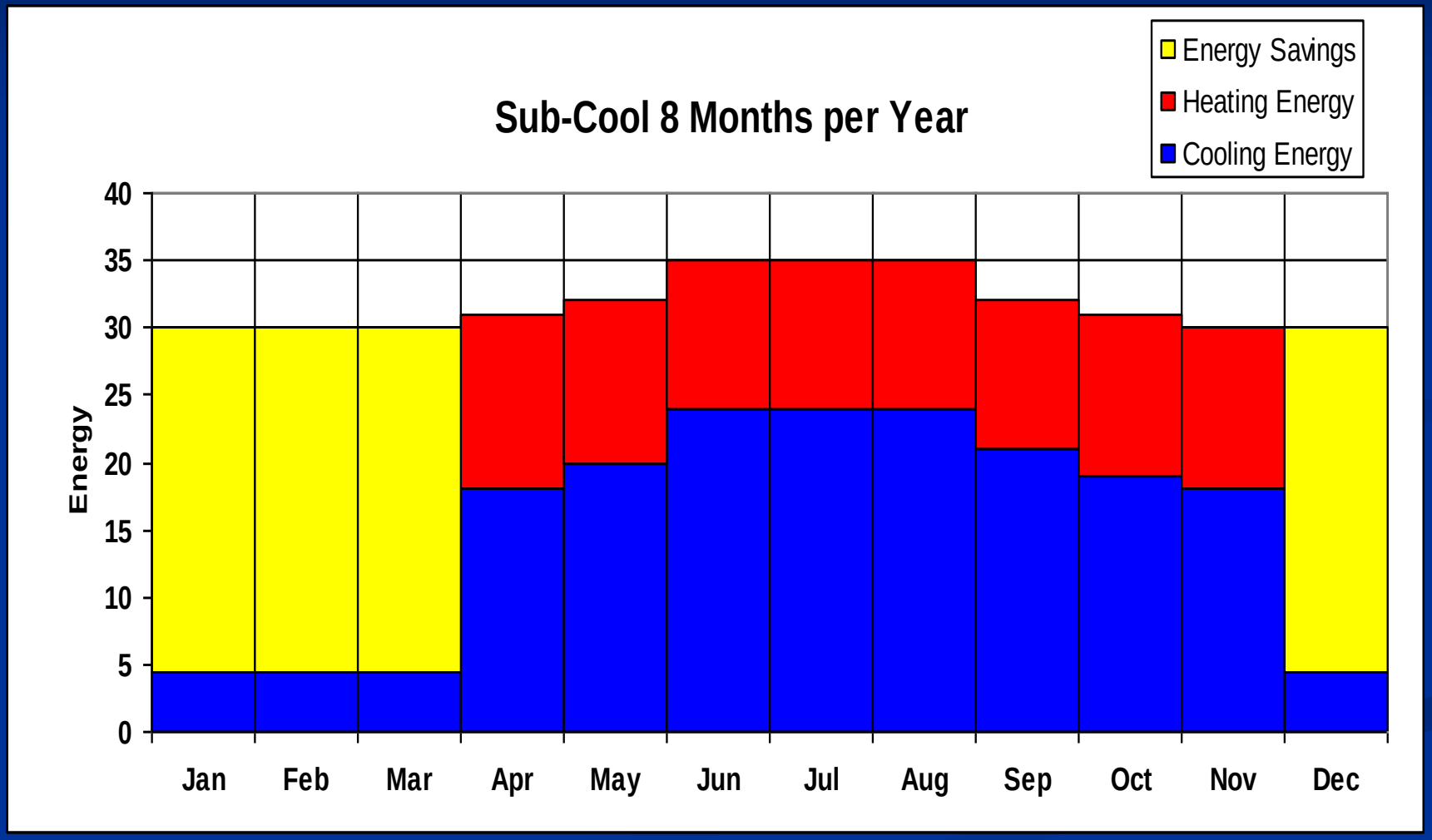




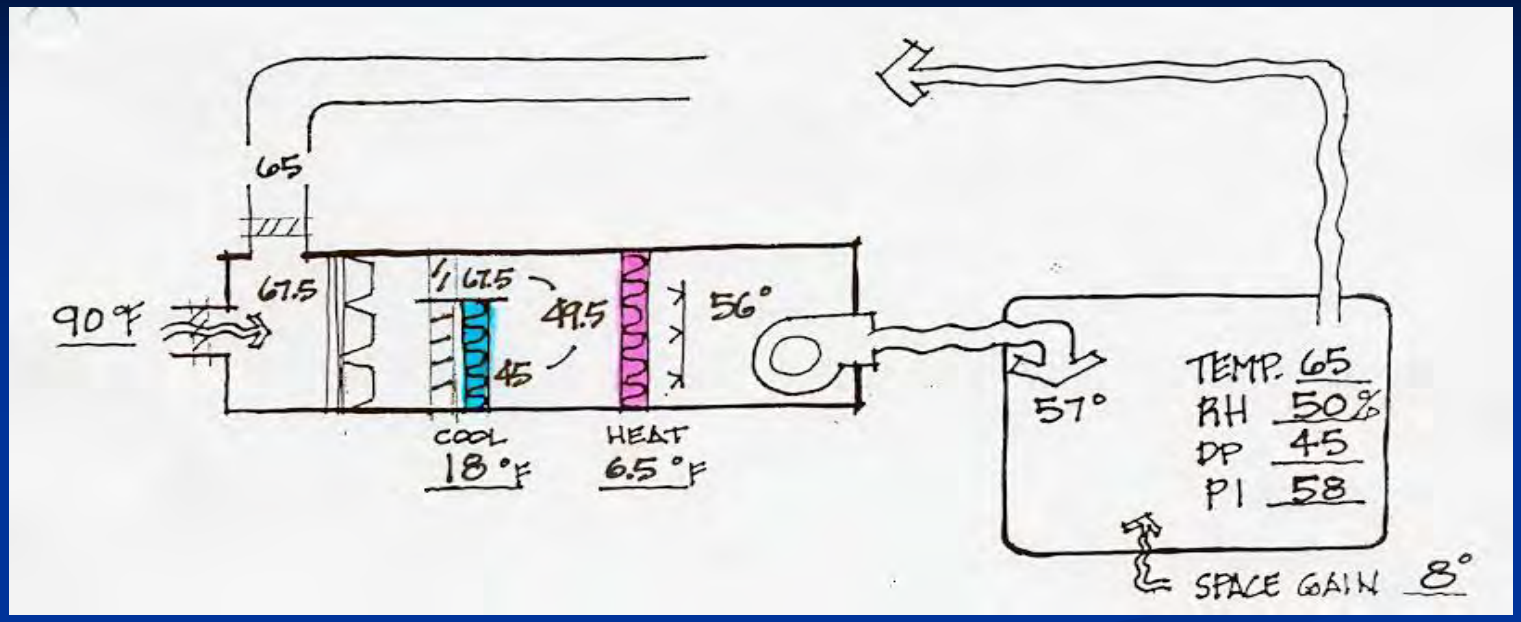
T	RH	DP	PI
65	49	45	58
65	35	37	85
65	35	37	85

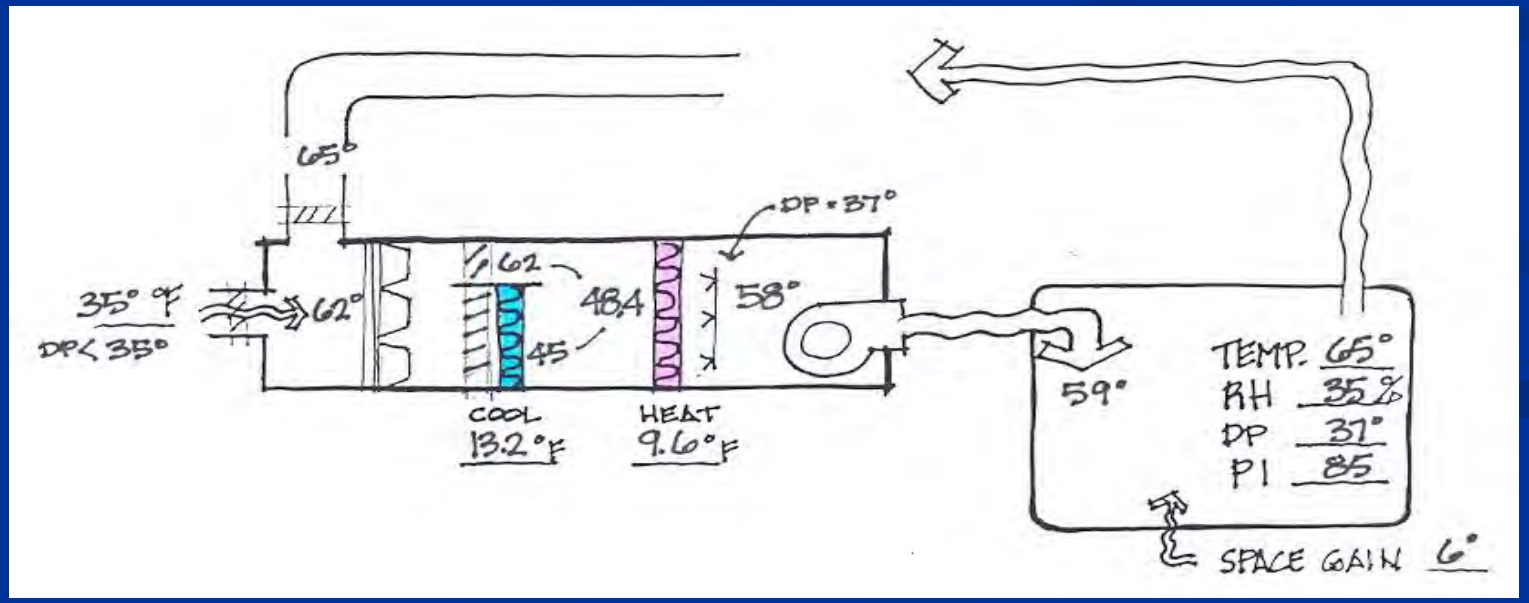
Sub-Cool/Reheat

65 deg. Space, 50% RH Summer, 35% RH Winter

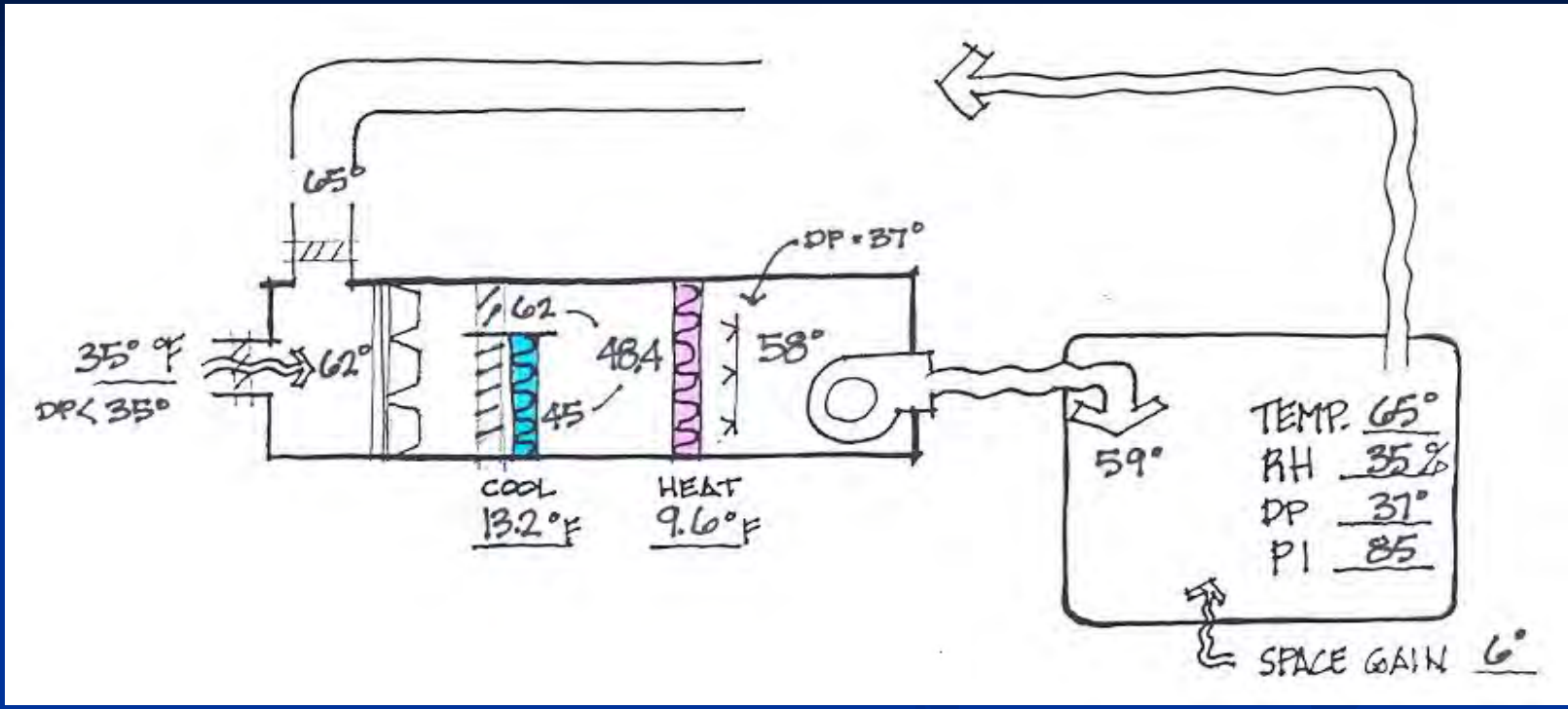


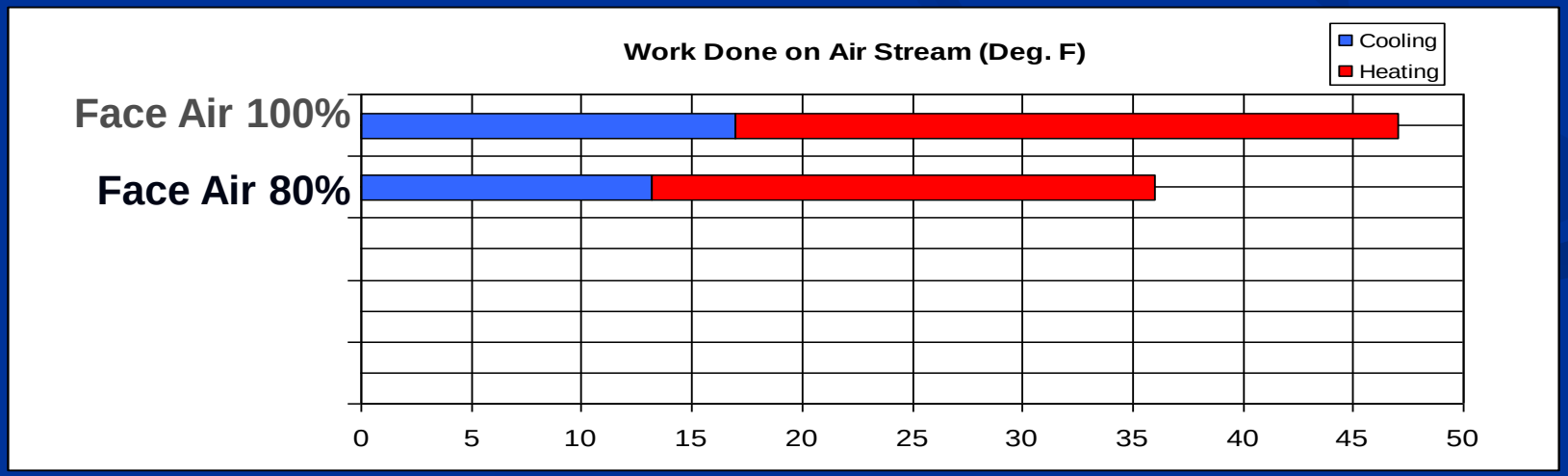
Face & By-Pass: Low Outdoor Dewpoint Temp.



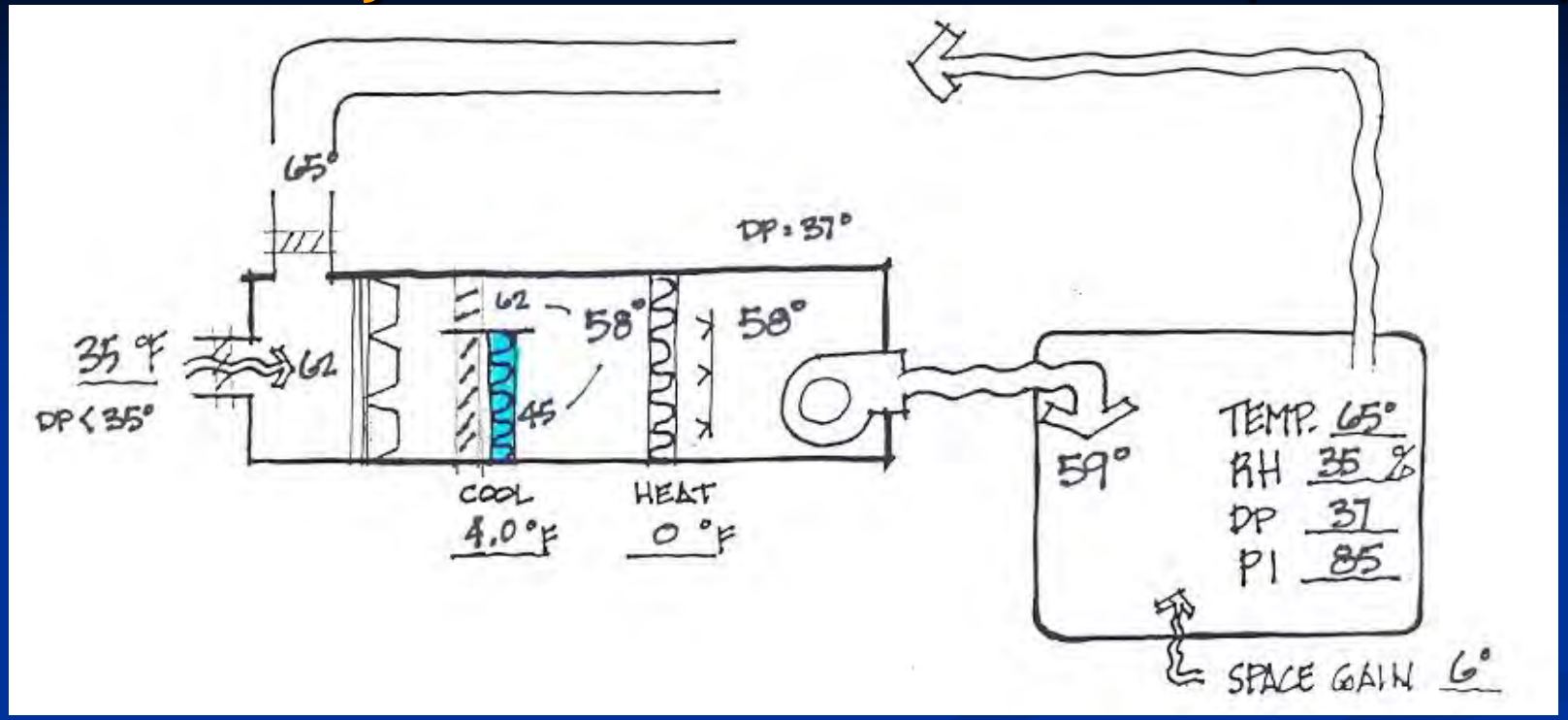


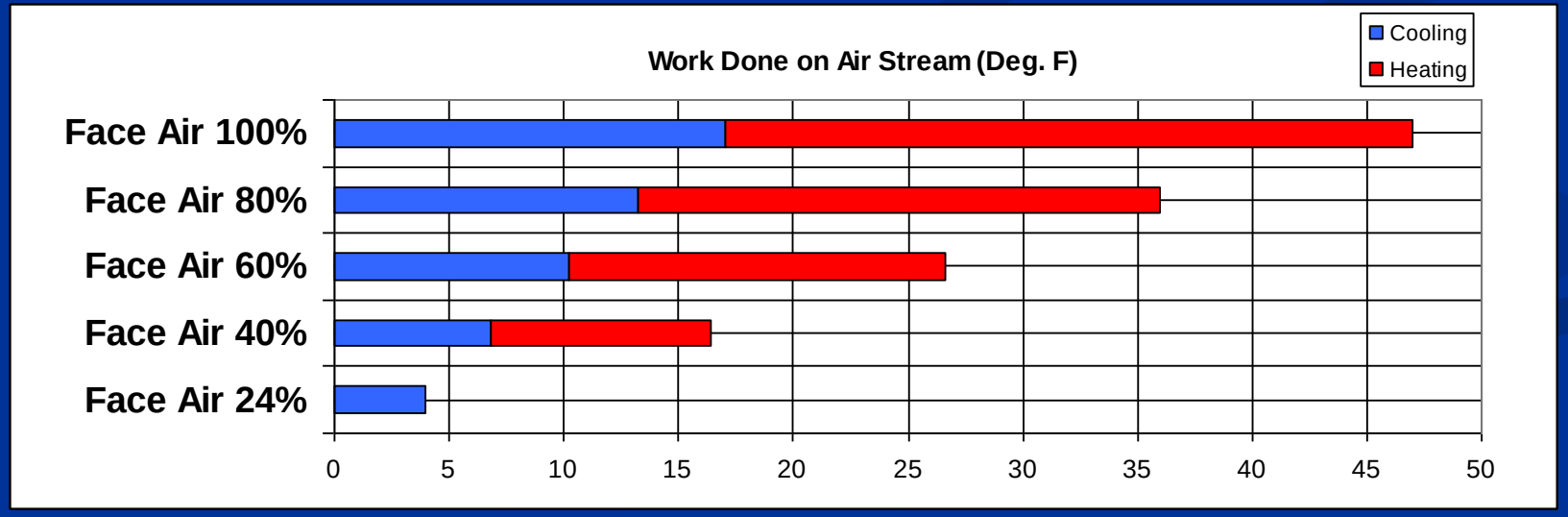
Face & By-Pass: Low Outdoor Dewpoint Temp.





Face & By-Pass: Low Outdoor Dewpoint Temp.



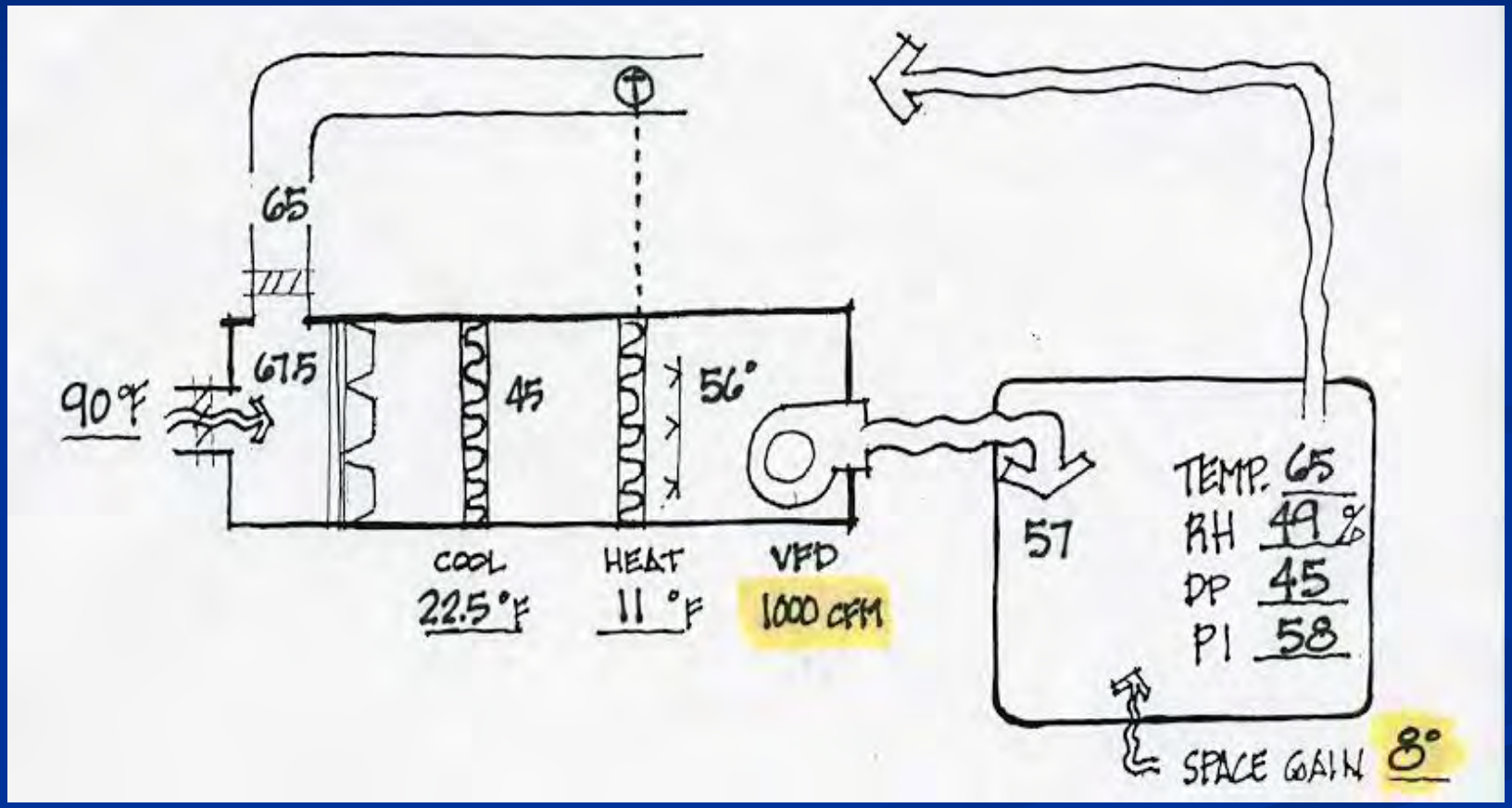


Analyze “System” Performance

- How much air is necessary…and when?

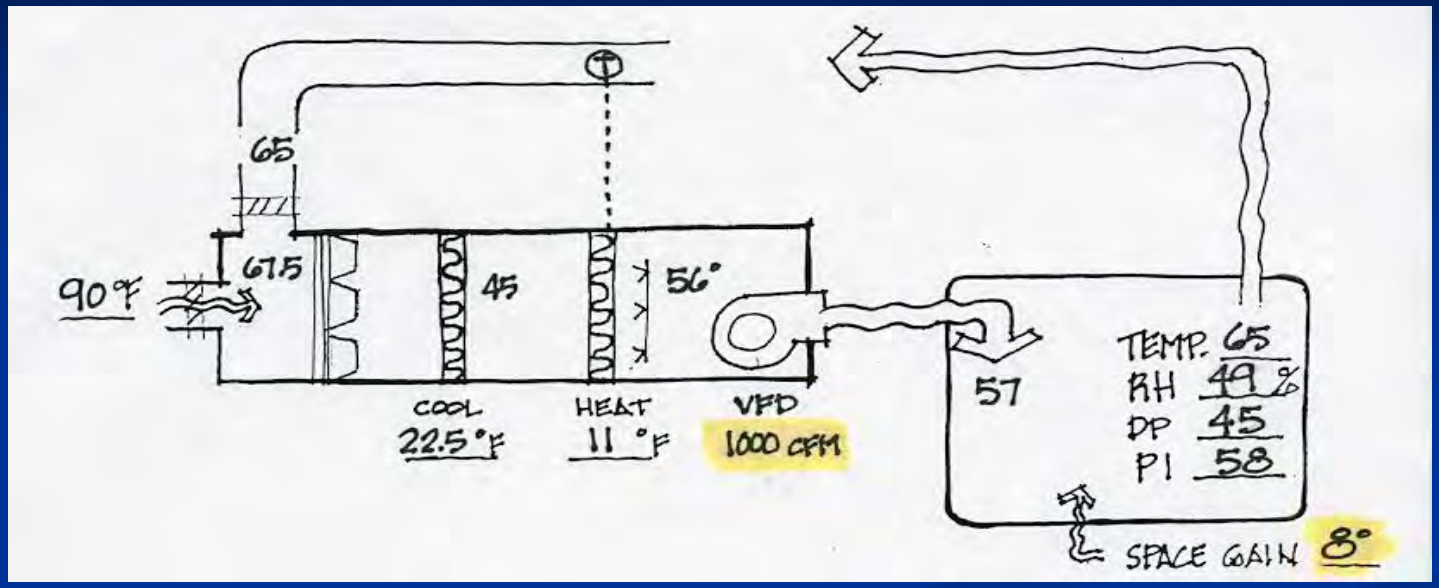
Sub-Cool & Reheat: with Variable Frequency Drive (VFD)

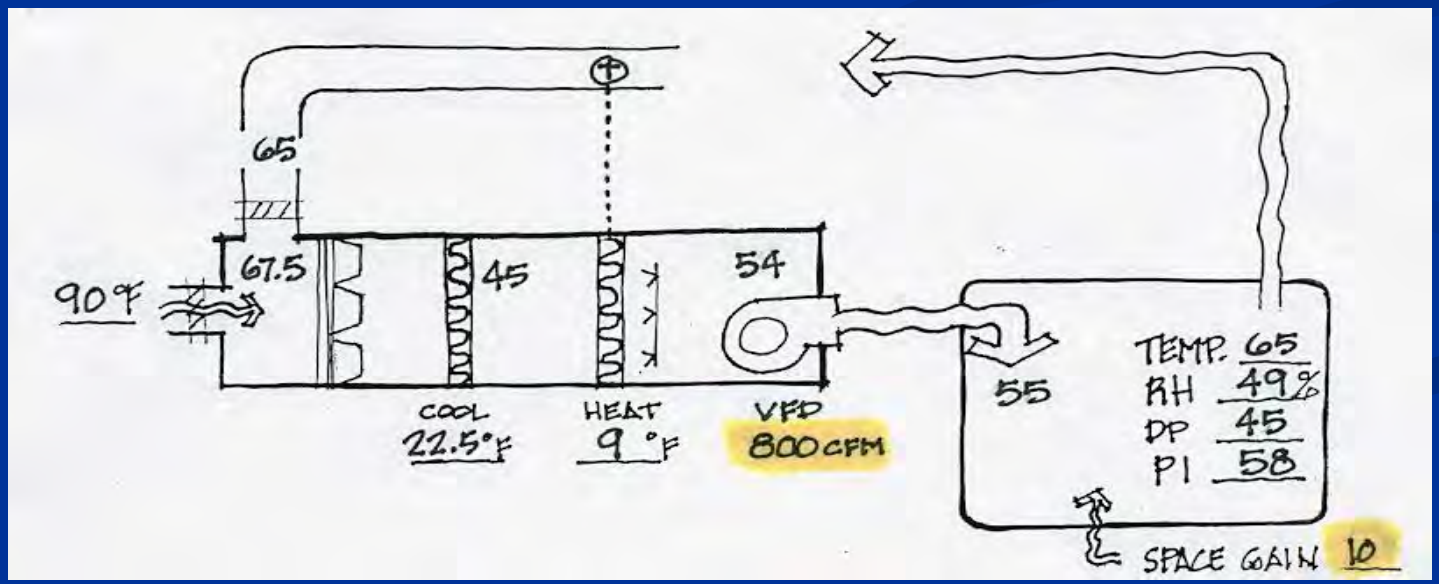
Summer Operation at 100% of Air Flow



Sub-Cool & Reheat: with Variable Frequency Drive (VFD)

Summer Operation 100% vs. 80% of Air Flow





Sub-Cool & Reheat: with Variable Frequency Drive (VFD)

Potential Energy Savings

% Reduction				Entering Air	
Air Volume	Cooling Energy	Reheating Energy	Fan Energy	Temp.	RH
0%				57.0	64%
10%	10%	17.4%	35%	56.1	67%
20%	20%	34.5%	55%	55.0	69%
30%	30%	51.6%	70%	53.6	73%
40%	40%	68.9%	82%	51.7	78%

Analyze “System” Performance

- How much air is necessary…and when?

  Possibly NONE…sometimes.

Summary

Definition of Optimal:

- Best Possible Climate
- While Doing the Least Possible Work
- On the Least Possible Volume of Air
- For the Least Possible Time

Summary

My climate control system is operating optimally when:

My existing system is producing the best possible climate

It is doing no more work than necessary

It is working on no more air than necessary

Its time of operation is no longer than necessary

How To Optimize

Collect and Analyze Space Data:

- Measure space temperature & RH
- Use IPI tools to quantify climate

Understand Your Control System & Climate

- Draw a cartoon
- Analyze annual weather data

Collect & Analyze Performance Data

- Add data to cartoon
- Source: BMS, sensors, data loggers

Experiment!!!

Summary

The benefits of optimal operation are:

- Enhanced collections life

Or

- Reduced energy consumption

Or

- Both!