Field Monitored Performance Data for an All-Electric Desiccant System

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Overview

- Objectives
- Describe All-Electric Desiccant System
- Two Test Sites in New York State
  - providing makeup air in two restaurants
- Monitoring Approach
- Performance Results
- Summary

Project Objectives

- Monitor Performance of All-Electric Desiccant System
  - determine energy and water use
  - measure capacity and efficiency in various operating modes
  - measure intermediate points to confirm system operates as expected
- Measure Space Conditions to Determine Impact of Desiccant Operation

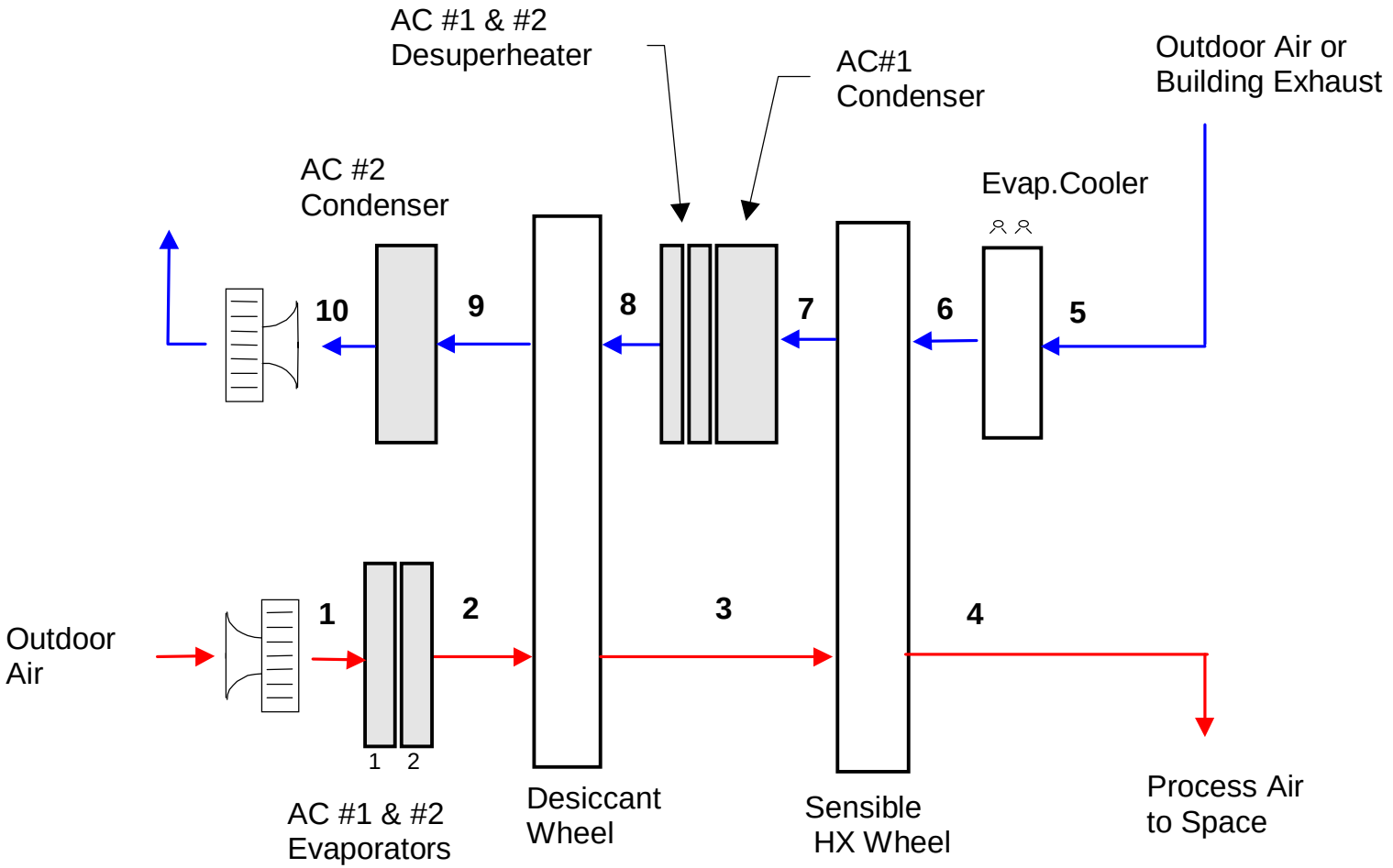
All-Electric Desiccant System

- Hybrid System Combining Desiccant and Vapor-Compression Technologies
- Uses Condenser Waste Heat to Regenerate the Desiccant Wheel (140°F regeneration)
- Significant Latent Capacity (SHR = 0.5 @ 95°F DB/ 75°F WB
- Well Suited to Ventilation Pretreatment

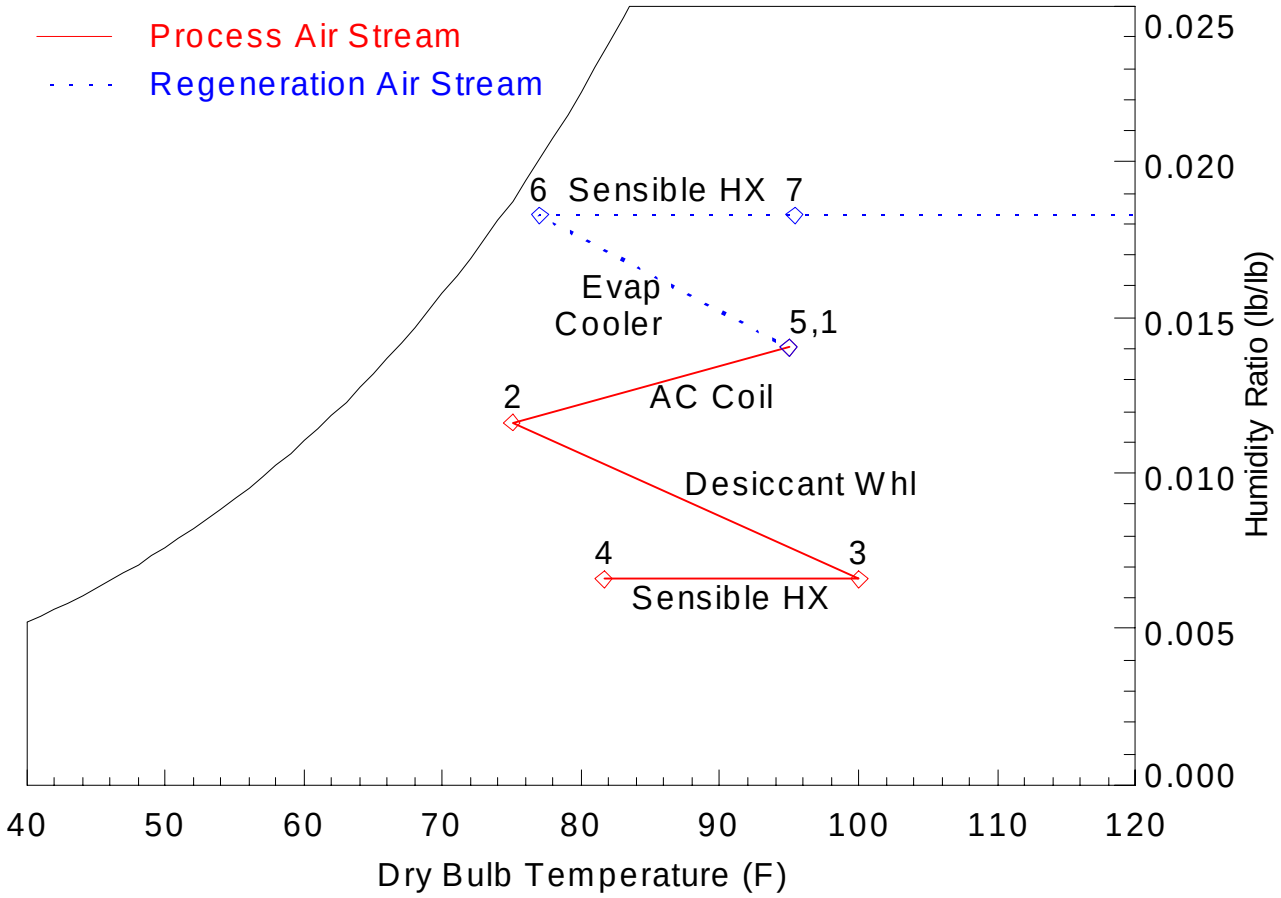
System Specifications

- 2,000 cfm Process Air Flow
- Nominal Capacity: 7 tons
- Specifications:
  - two 3.5 ton scroll compressors
  - desiccant wheel: 47 in. diameter, 5.5 in. deep
  - sensible HX wheel & regen evaporative cooler
  - 1.5 HP fans (process & regen)
  - unit dimensions: 14 ft x 5 ft x 5 ft

All-Electric Desiccant System



Psychrometric Process



Site #1: Fast-Food Restaurant

Tarrytown, NY

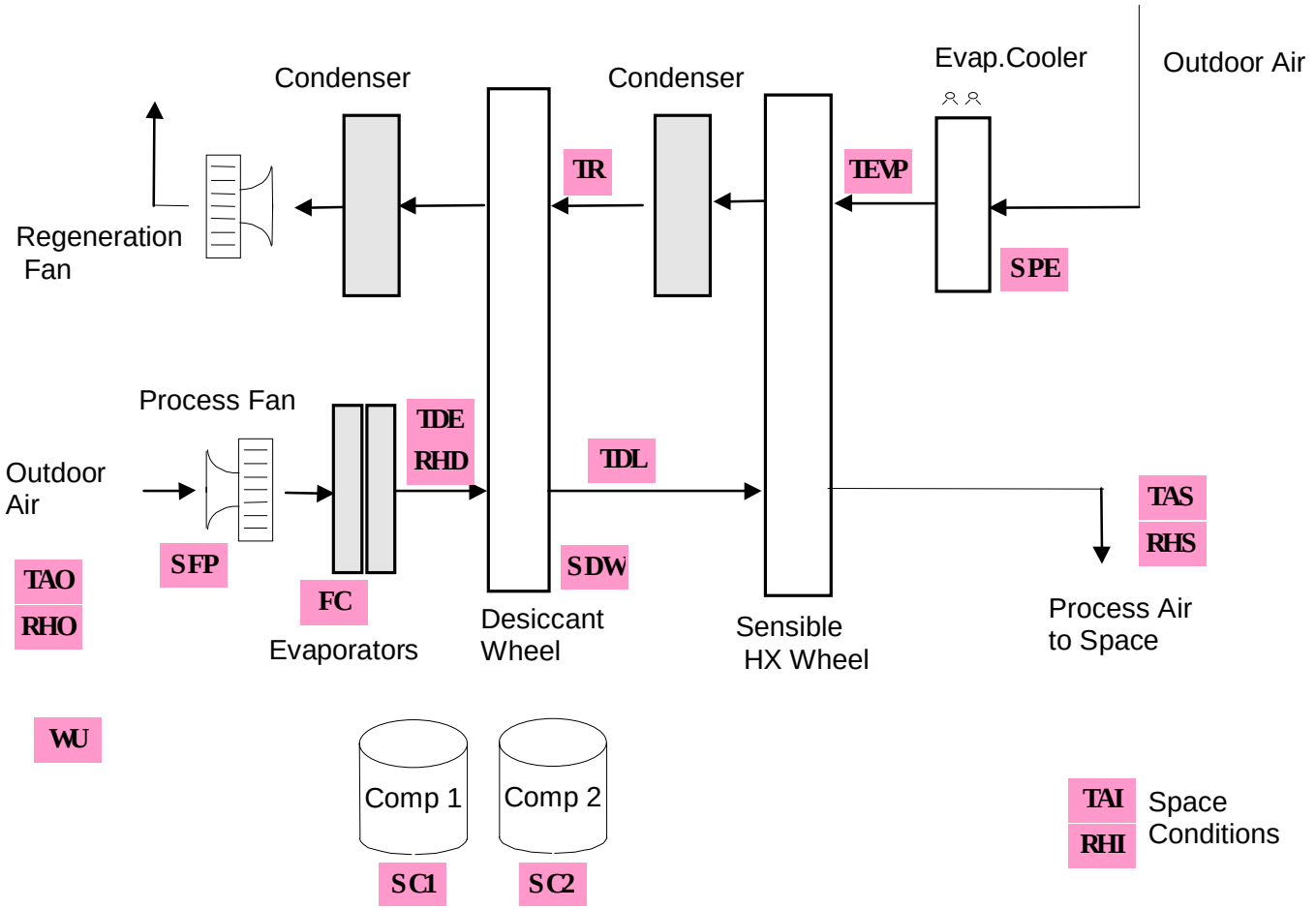
- 4,200 ft^2 building
- three rooftops: 22 tons
- needed make-up air due to kitchen exhaust hoods
- added desiccant system to supply make-up air into return-side of two rooftop units

Site #2: Pizza Shop/Deli

Rochester, NY

- 2,000 ft^2 building
- needed make-up air for kitchen exhaust hood
- added desiccant system and ductwork to supply fresh air directly to space

Monitored Data Points



Data Points:

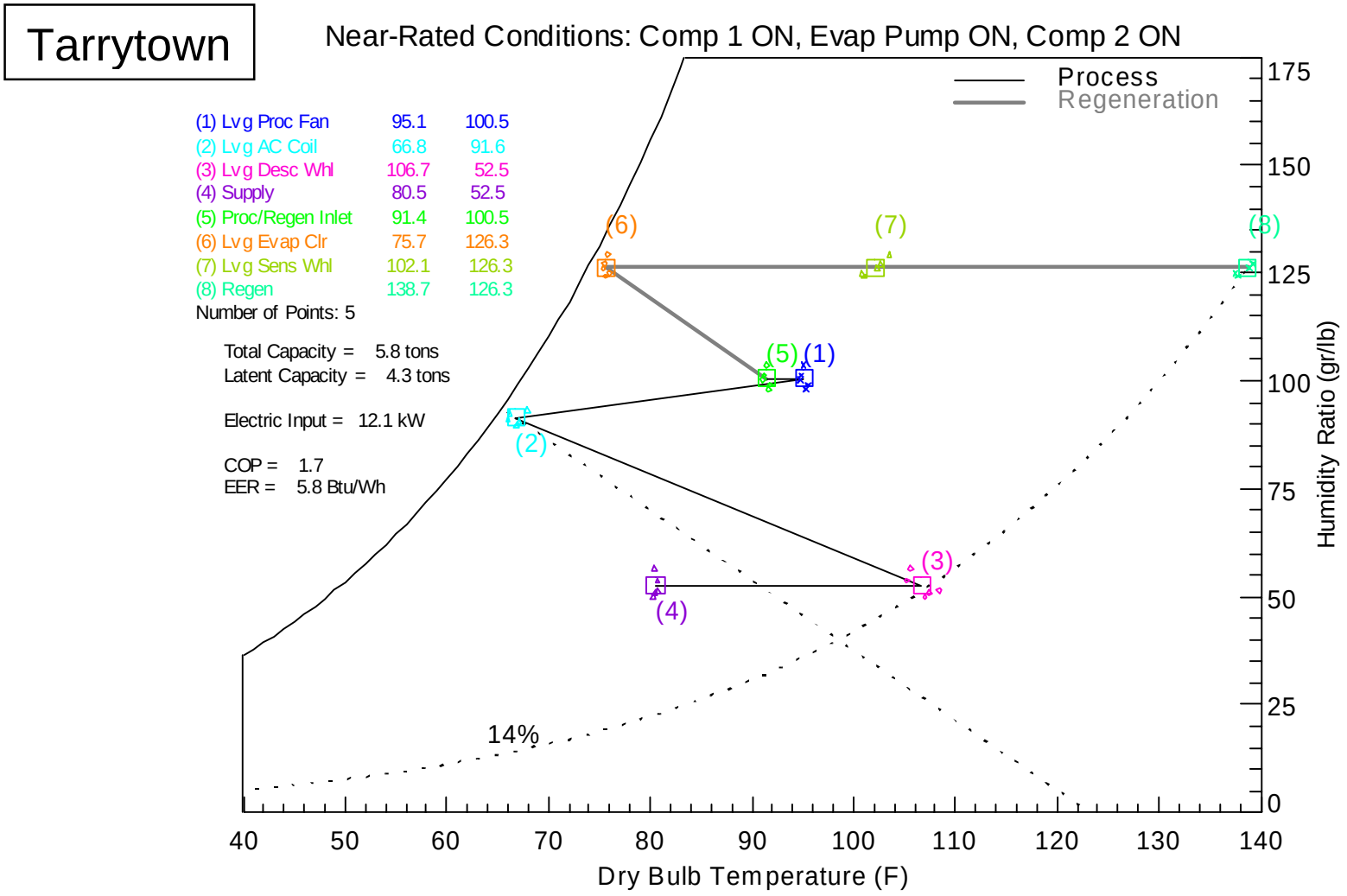
(4) RH
(1) power
(7) temp
(5) status
(1) condensate

Monitoring & Data Collection

- Installed Dedicated Data Acquisition System
  - sampled sensors every 3 seconds
  - recorded 15-minute and “change-of-state” data
  - data retrieved each night by modem
- Data Collection Period: May to Nov 1996
- Data Analysis
  - used psychrometric process “rules” to infer unmeasured state points in system

Near-Design Performance

Tarrytown

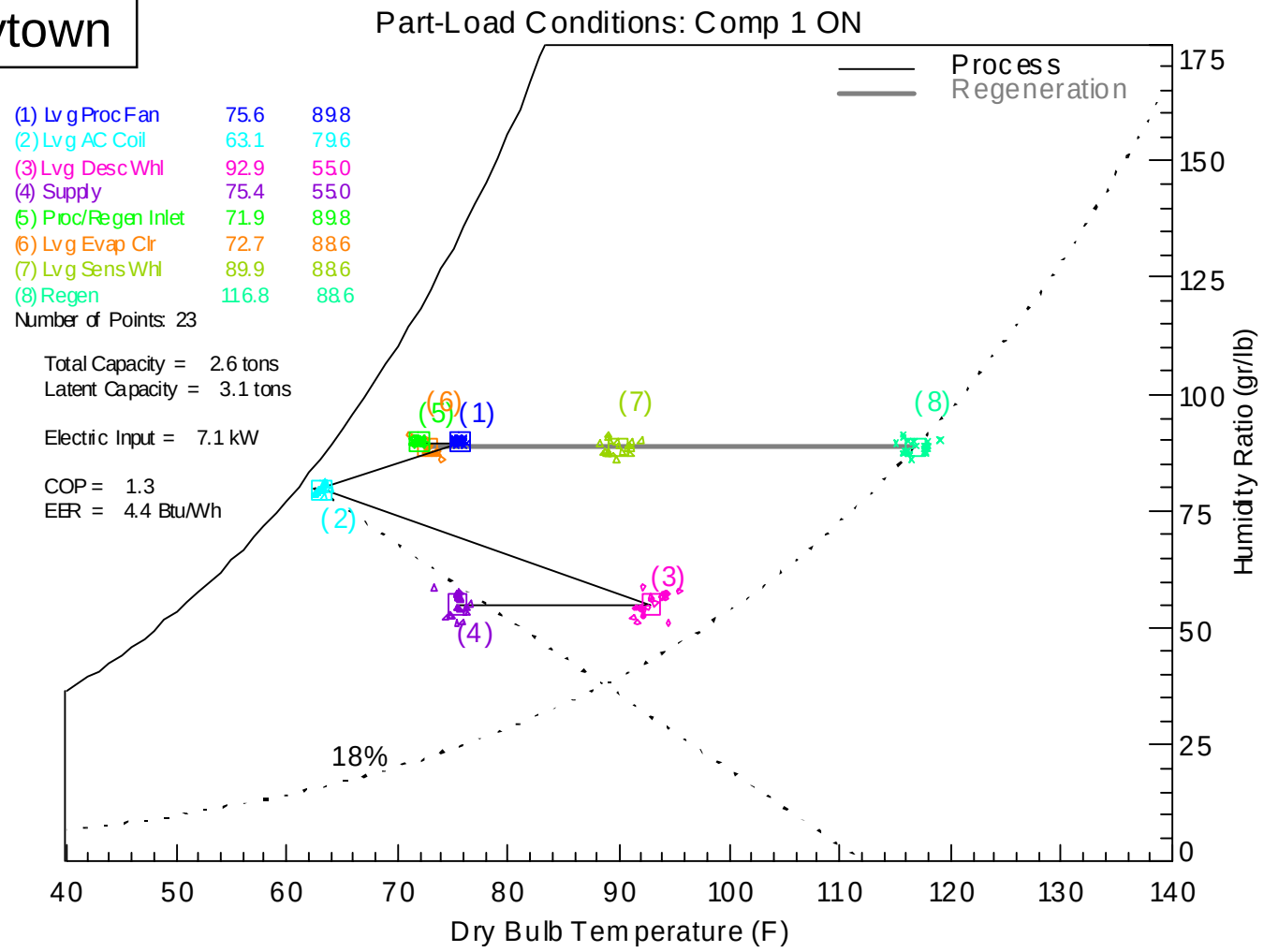


Near-Design Performance

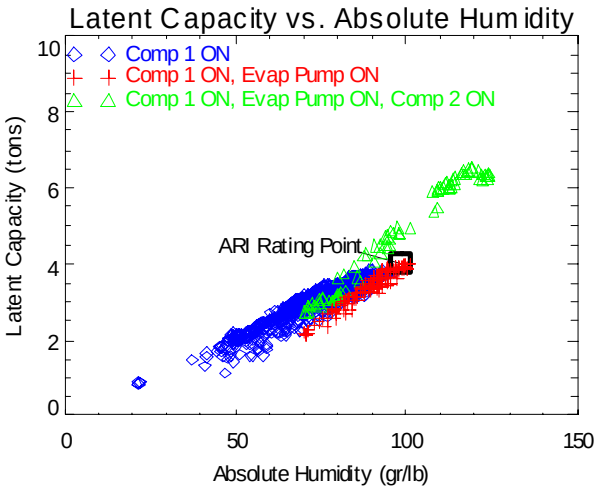
	Rochester	Tarrytown
Process Inlet		
Dry-Bulb Temperature (ºF)	82.6	91.4
Wet-Bulb Temperature (ºF)	71.3	74.4
Process Outlet (Supply)		
Dry-Bulb Temperature (ºF)	77.7	80.5
Absolute Humidity (Gr/lb)	55.1	52.5
Air Flow Rate (cfm)	2,000	1,575
Total Capacity (tons)	**5.7**	**5.8**
Latent Capacity (tons)	4.8	4.3
Electrical Input (kW)	11.3	12.1
EER (Btu/Wh)	**6.1**	**5.8**
Grain Depression (Gr/lb)	42.3	48.0

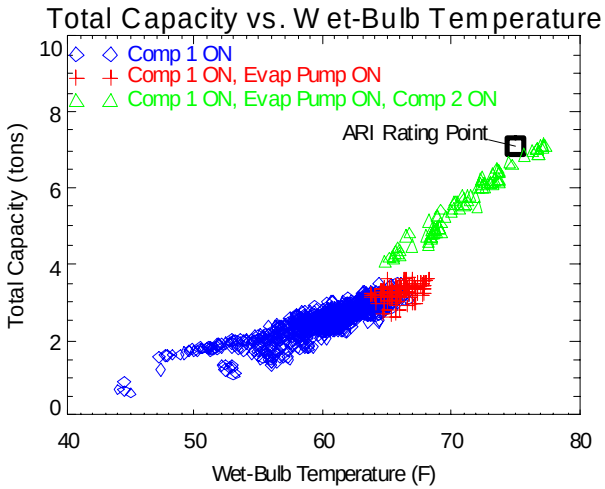
Off-Design Performance

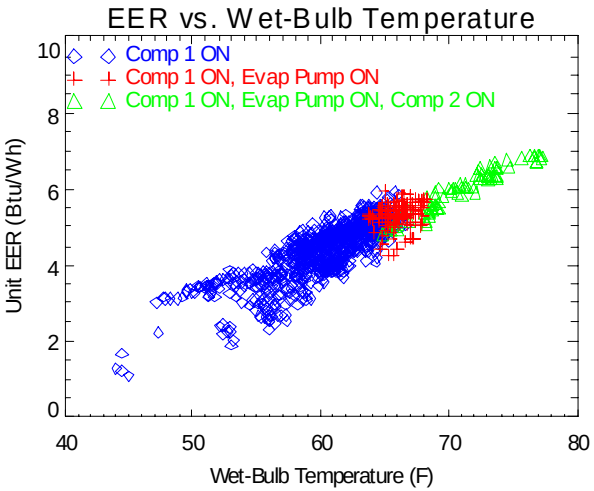
Tarrytown



Performance Trends







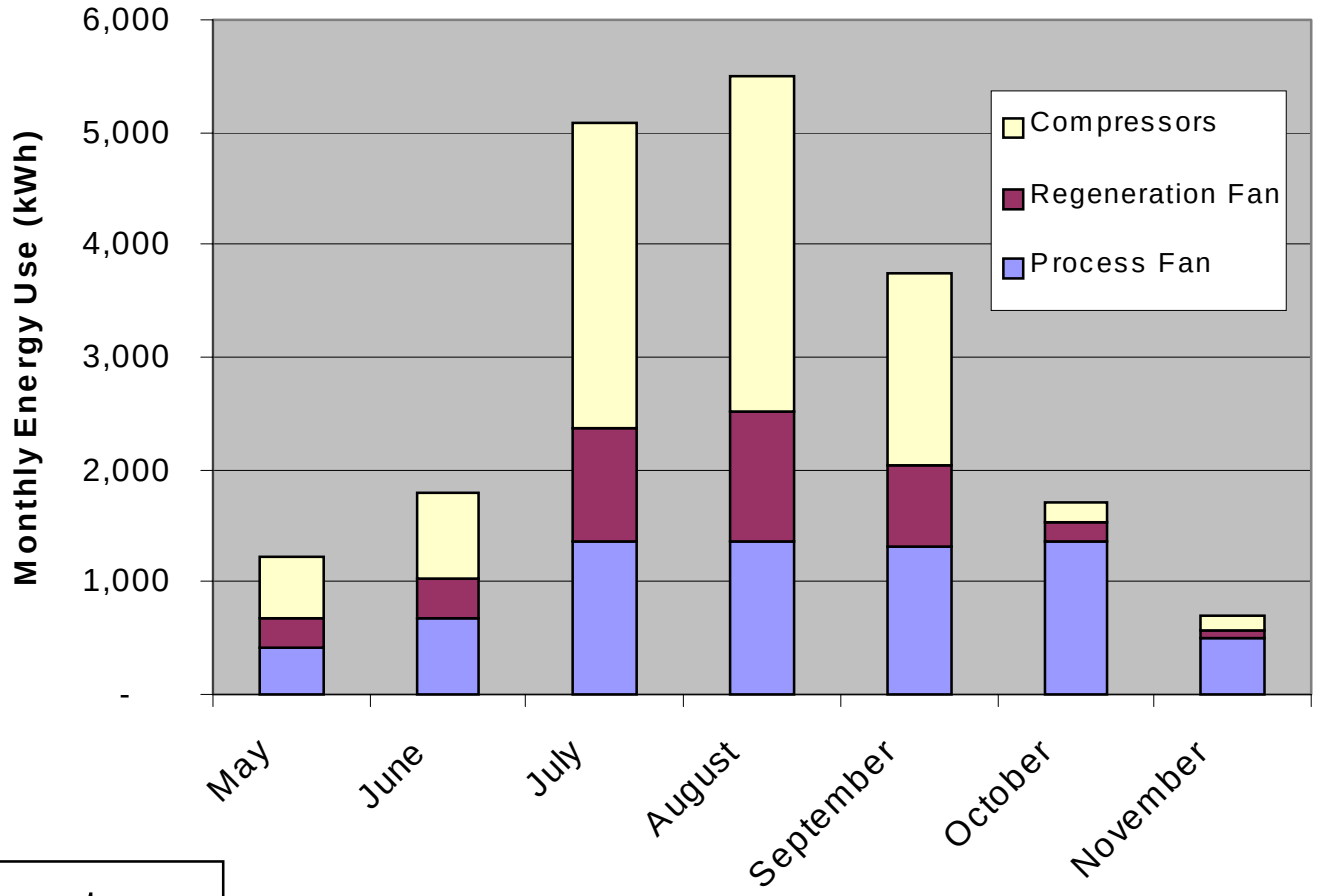
Rochester

Seasonal Average Performance

	Rochester[1]	**Tarrytown**
Water Use (gallons)	871	1,788
Electricity Use (kWh)	12,798	19,749
Runtime[2] (hours)	1,701	2,253
EER[2] (Btu/Wh)	4.96	4.28
Sensible Heat Ratio (-)	0.05	0.01

Note: 1 – Rochester system stopped operating on August 5, 1996
2- While In Dehumidification Mode

Energy Use Breakdown

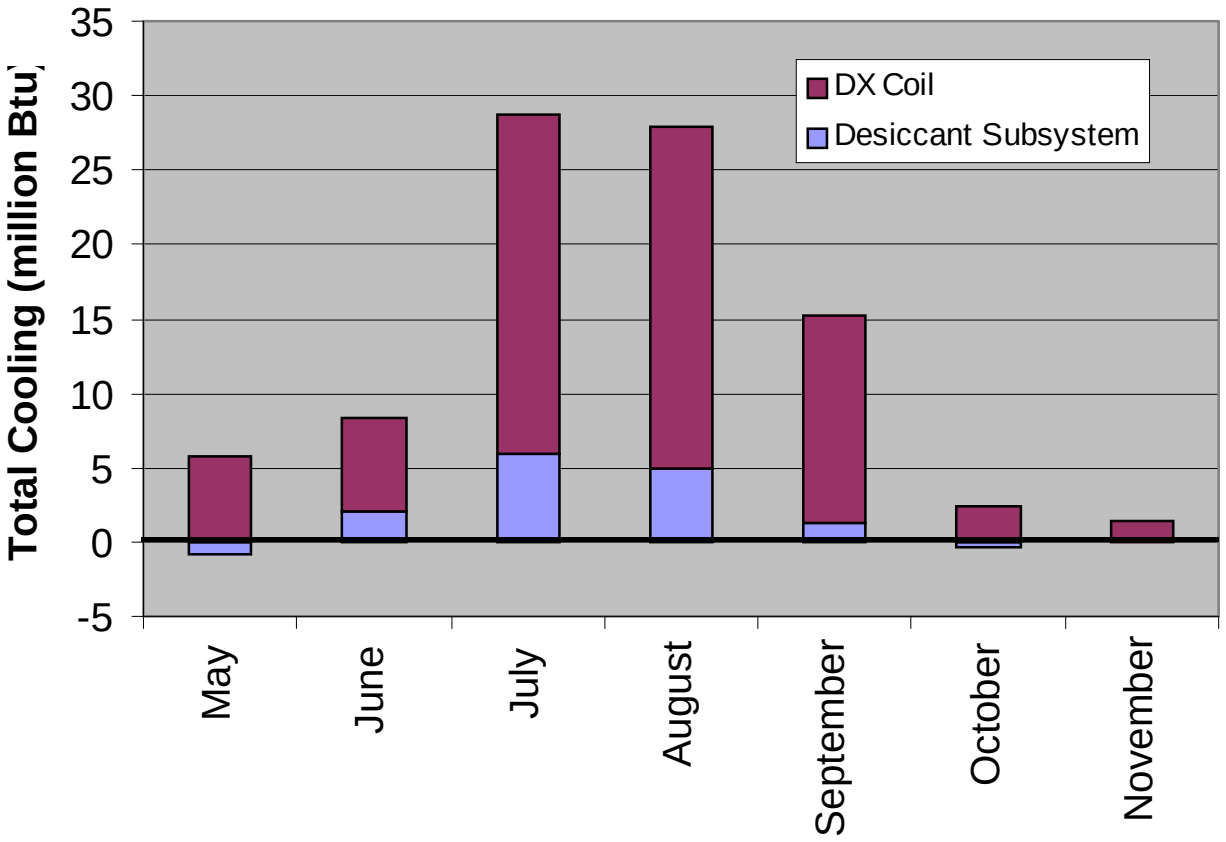


Tarrytown

Fan Power Issues

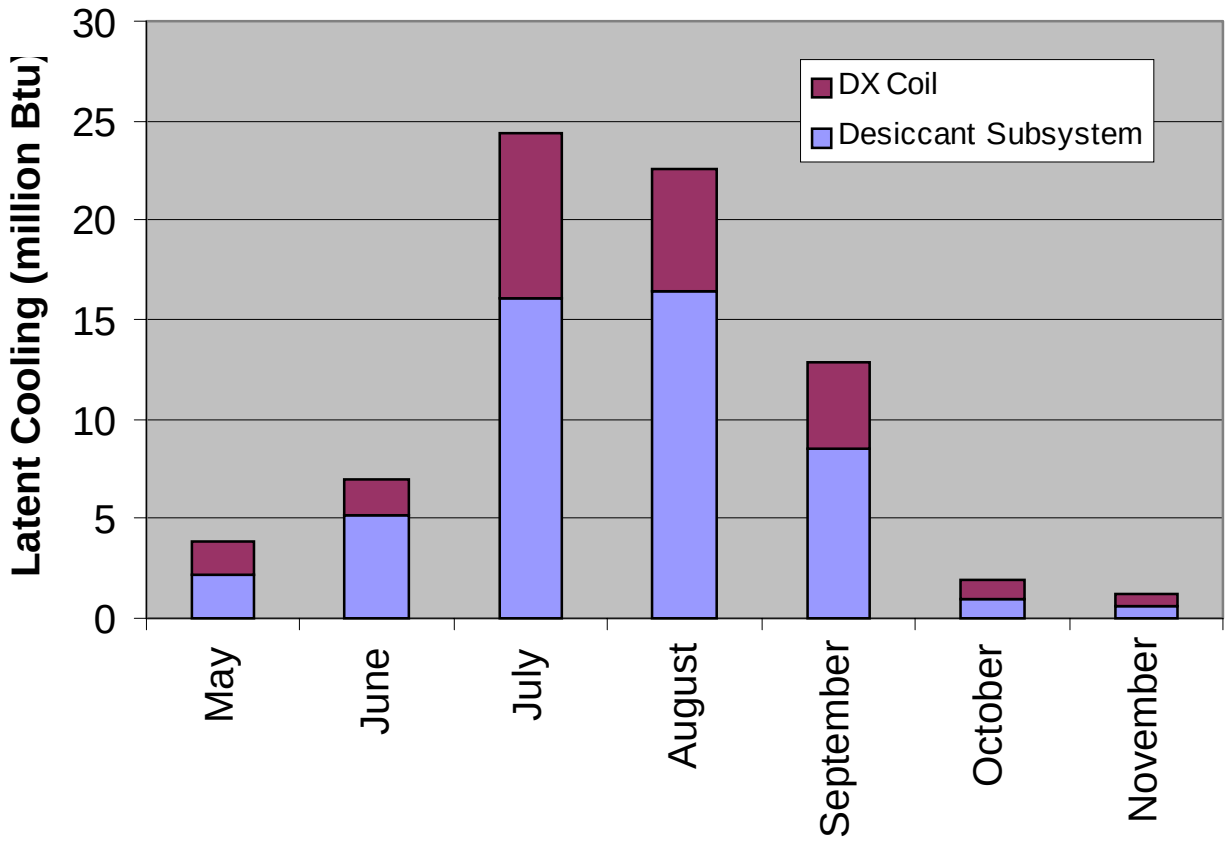
- Process Fan Accounted for 35% of Energy Use in Tarrytown
- Process Fan 1.8 kW ⇒ 1.1 Watts per cfm
  - twice the fan power of conventional rooftop systems (DOE-2 assumes 0.55 Watts per cfm)
- Fan Power "Penalty" for Supplying Ventilation Air Through Desiccant System
  - for continuous operation, ½ of fan power equals 7,800 kWh per year

Total Capacity Breakdown



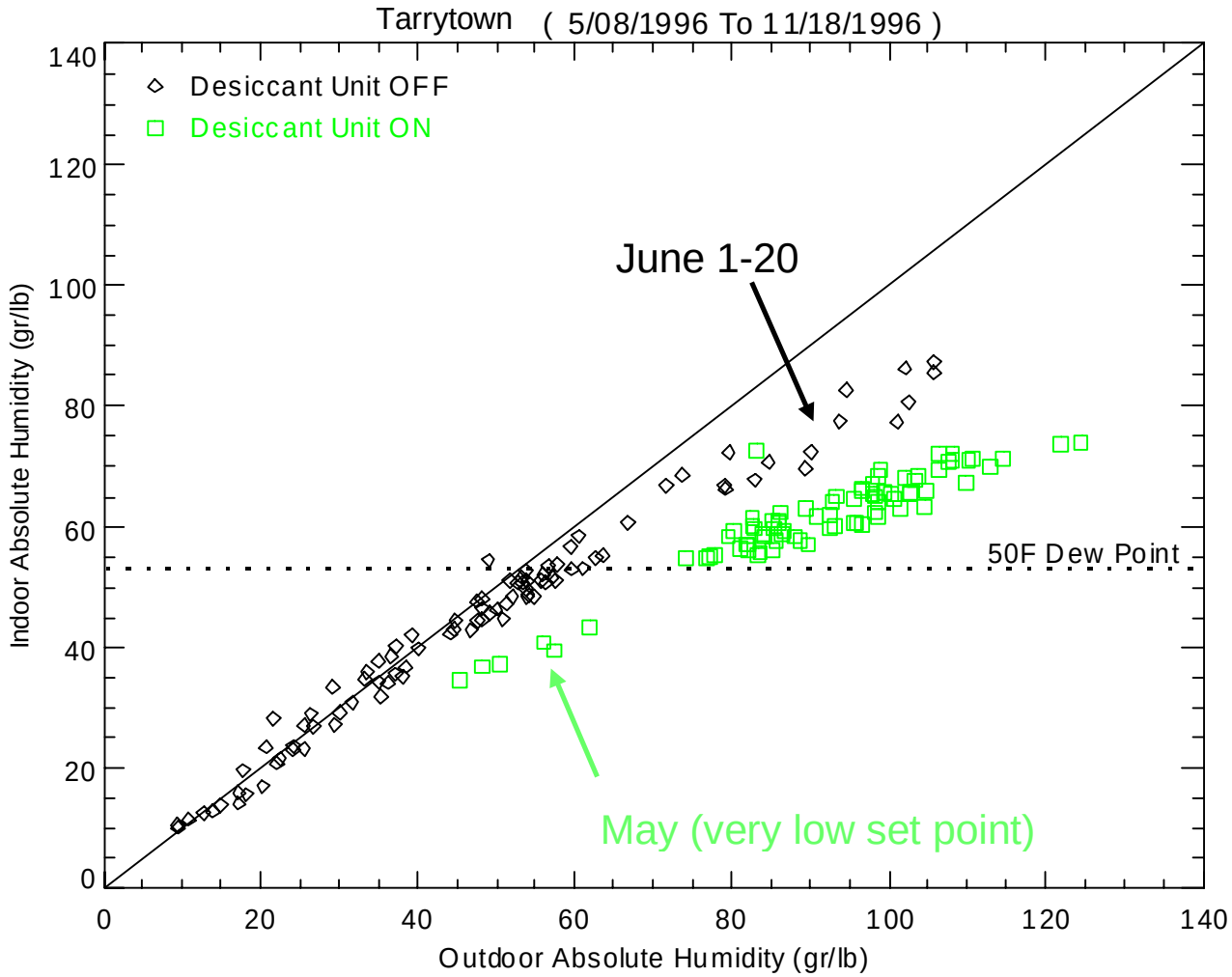
Tarrytown

Latent Capacity Breakdown

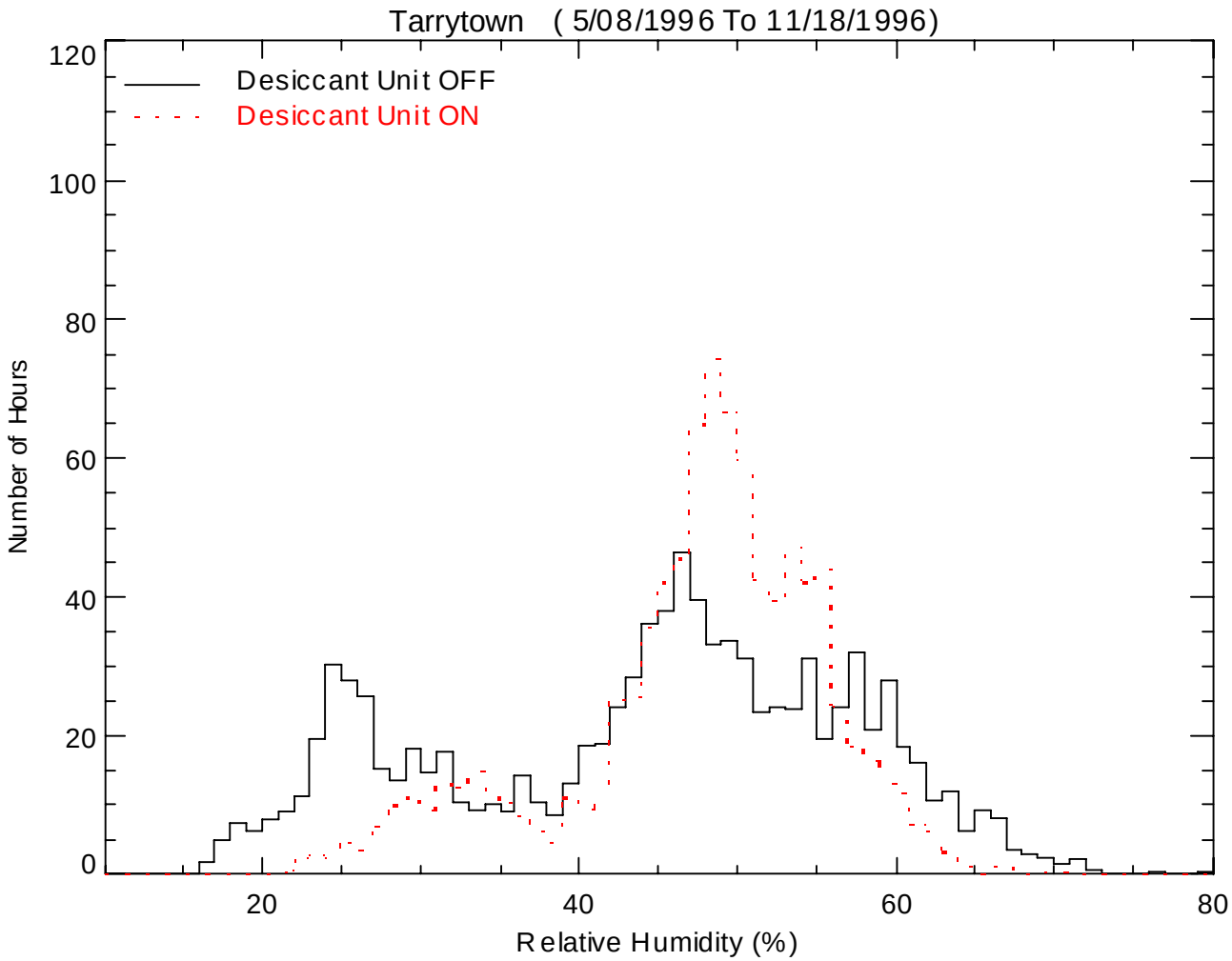


Tarrytown

Impact on Indoor Humidity



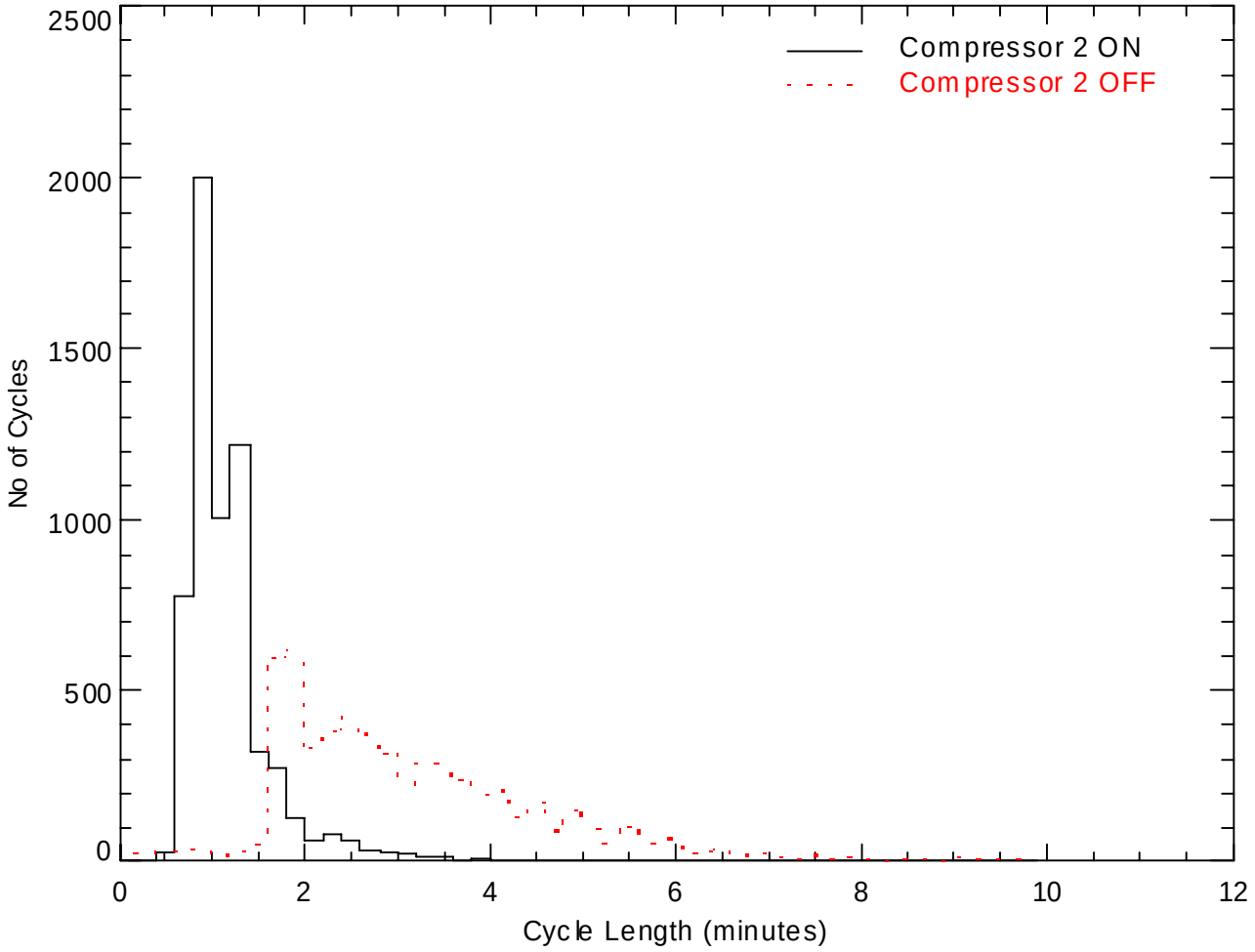
Space Humidity



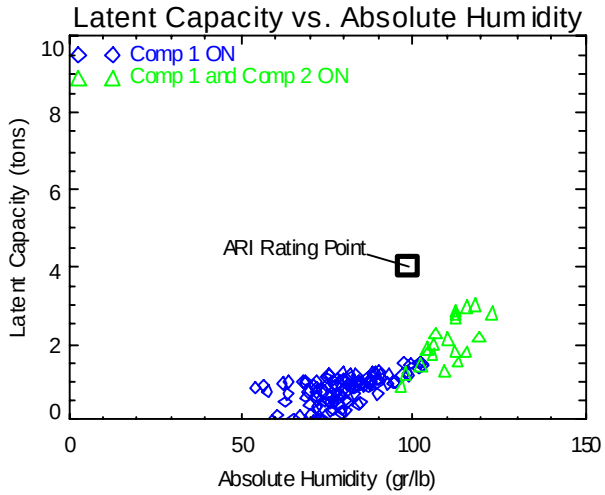
Compressor Cycling Data

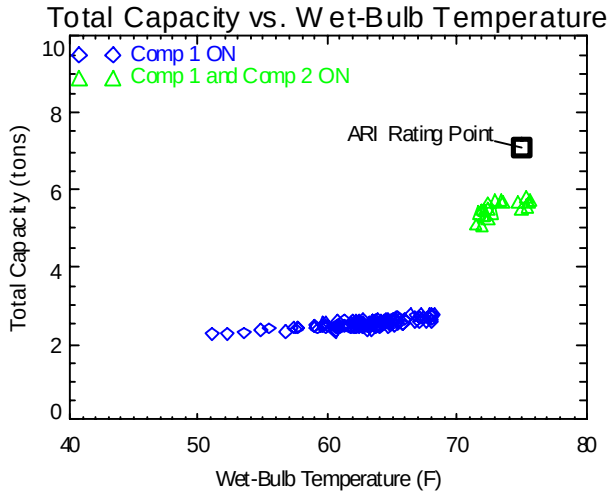
Date	Time at End of Mode	Mode Duration (min)	Operating State				
			Process Fan	DEHUM	Comp 1	Comp 2	Evap Cooler
7/8/96	11:29:57	1.3	ON	ON	ON	-	-
7/8/96	11:32:39	2.7	ON	ON	ON	-	ON
7/8/96	**11:33:33**	**0.9**	**ON**	**ON**	**ON**	**ON**	**ON**
7/8/96	11:34:09	0.6	ON	ON	ON	-	ON
7/8/96	11:39:03	4.9	ON	ON	ON	-	-
7/8/96	**11:39:48**	**0.75**	**ON**	**ON**	**ON**	**ON**	**-**
7/8/96	11:43:54	4.1	ON	ON	ON	-	-
7/8/96	**11:44:39**	**0.75**	**ON**	**ON**	**ON**	**ON**	**-**
7/8/96	11:48:15	3.6	ON	ON	ON	-	-
7/8/96	**11:49:03**	**0.8**	**ON**	**ON**	**ON**	**ON**	**-**
7/8/96	11:56:39	7.6	ON	ON	ON	-	-
7/8/96	**11:57:18**	**0.65**	**ON**	**ON**	**ON**	**ON**	**-**
7/8/96	12:01:33	4.25	ON	ON	ON	-	-
7/8/96	**12:02:15**	**0.7**	**ON**	**ON**	**ON**	**ON**	**-**

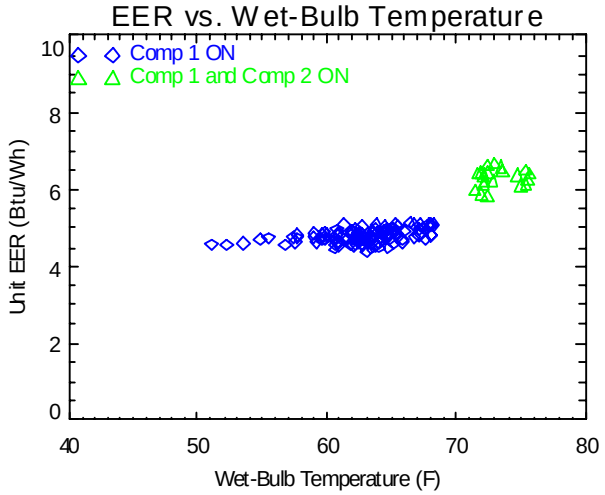
Compressor #2 Cycles too Fast



DX Coil Operating Alone







Performing as a 100% Fresh Air DX Unit:

Total Capacity: 6 tons
Latent Capacity: 2-3 tons

(for period when desiccant subsystem was off)

Summary

- System Provides about 6 tons with EER of 6 Btu/Wh at Rated Conditions (95°F DB/ 75°F WB)
- Capacity and Efficiency are Highest at Peak Conditions (Seasonal EER = 4-5 Btu/Wh)
- Desiccant System Lowered Space Humidity by as much as 20 gr/lb on humid days
- Fan Power “Penalty” Can Be Substantial

Remaining Questions

- How Does the All-Electric Desiccant System Compare to Other Technologies?
  - Increased operating costs compared to conventional base case systems?
  - Cost effective compared to other technologies (gas-fired desiccants, 100% fresh air units, sensible HX assisted AC, dual path, etc)?
- Are Building Owners Willing to “Pay” For Improved Humidity Control?
  - How bad are humidity conditions now?