Energy Saving Ideas in Refrigeration

2019 Columbus ASHRAE

Presenter

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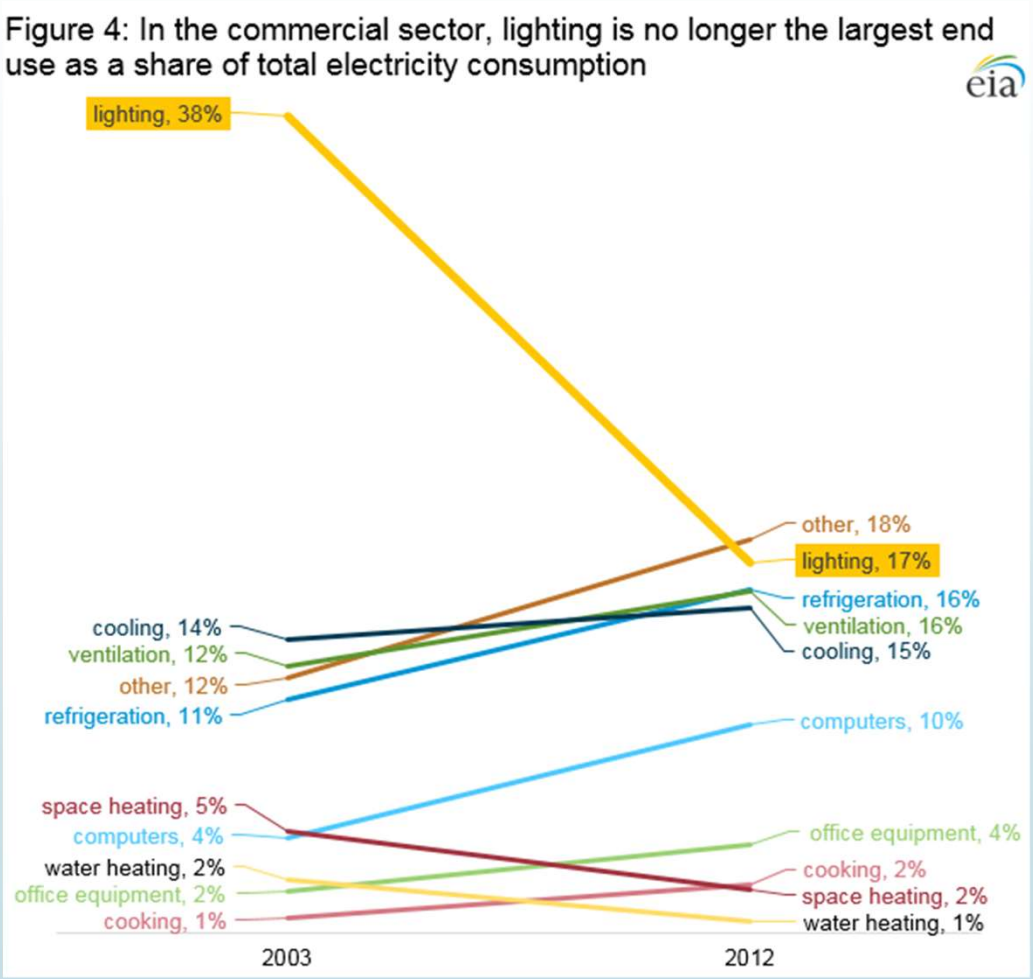
Lockheed Martin

Field Engineer

Electrical Usage in Commercial Buildings



Grocery Profits

- Where does the money go?
  - $1.00 sales
  - $0.75 cost of goods
  - $0.21 operating expenses
  - $0.02 other expenses
  - $0.02 earnings
  - Split for dividends and growth

Building

Commissioning pays!

- Retro-commissioning results in average annual energy cost savings $0.15 per sf.

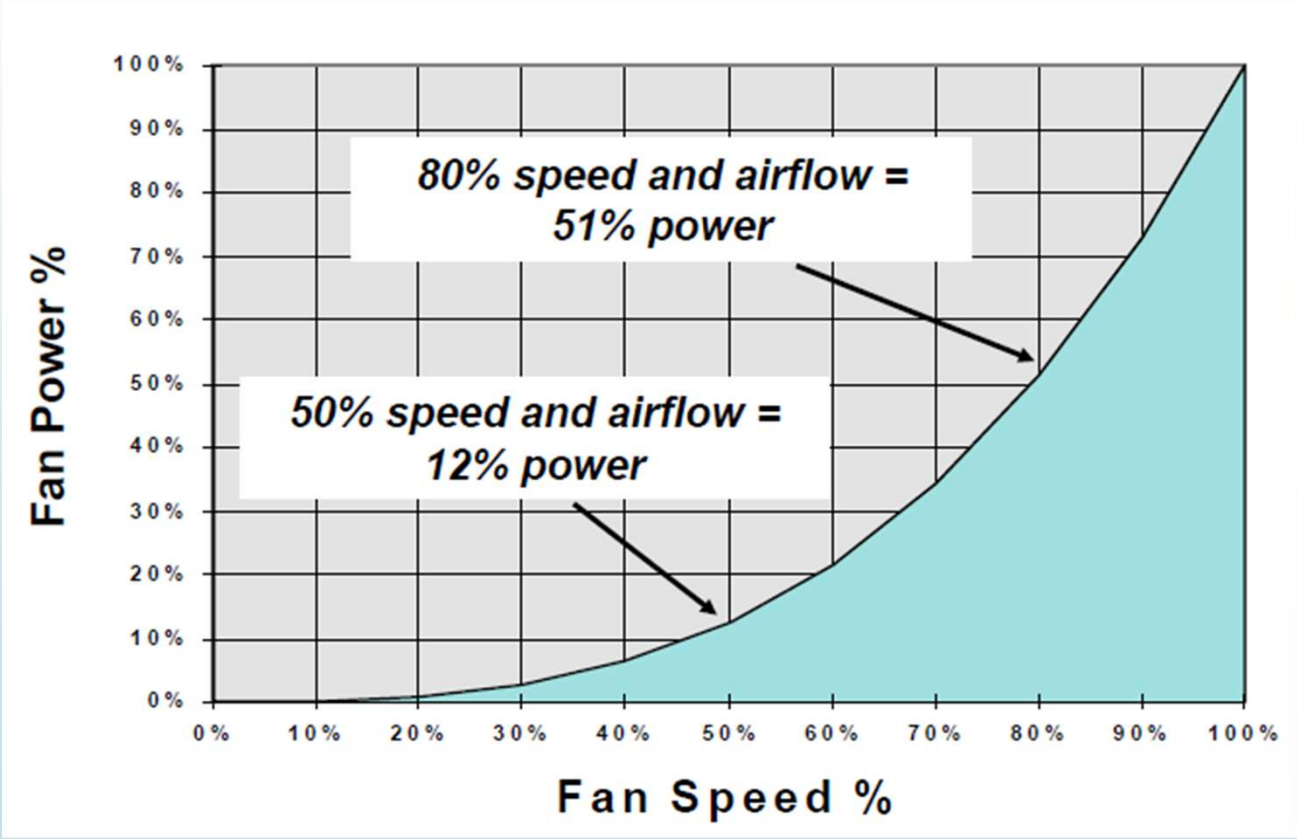
- ROI for an investment in retro-commissioning is 115%

- *NSF/IUCRC Center for Building performance and Diagnostics at Carnegie Mellon University

Variable Speed Fan Control

Third power relationship "Affinity law"

- Airflow varies directly with change in speed
- Air pressure varies with the square of change in speed
- Fan power varies with the cube of change in speed



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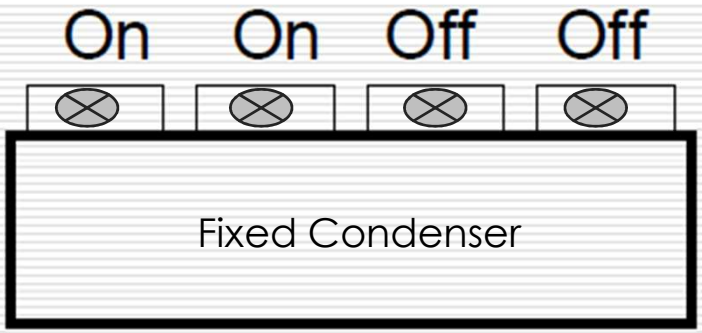
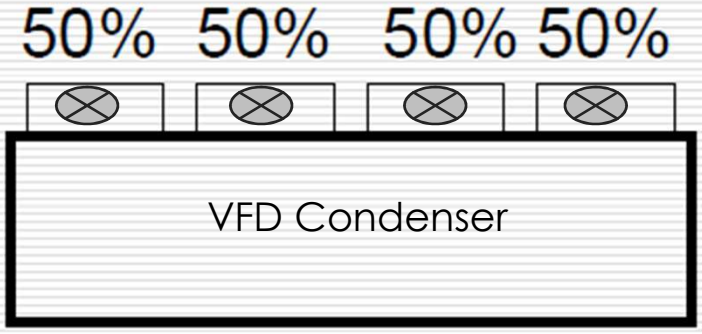


50% capacity
50% power

80 BTUH/Watt

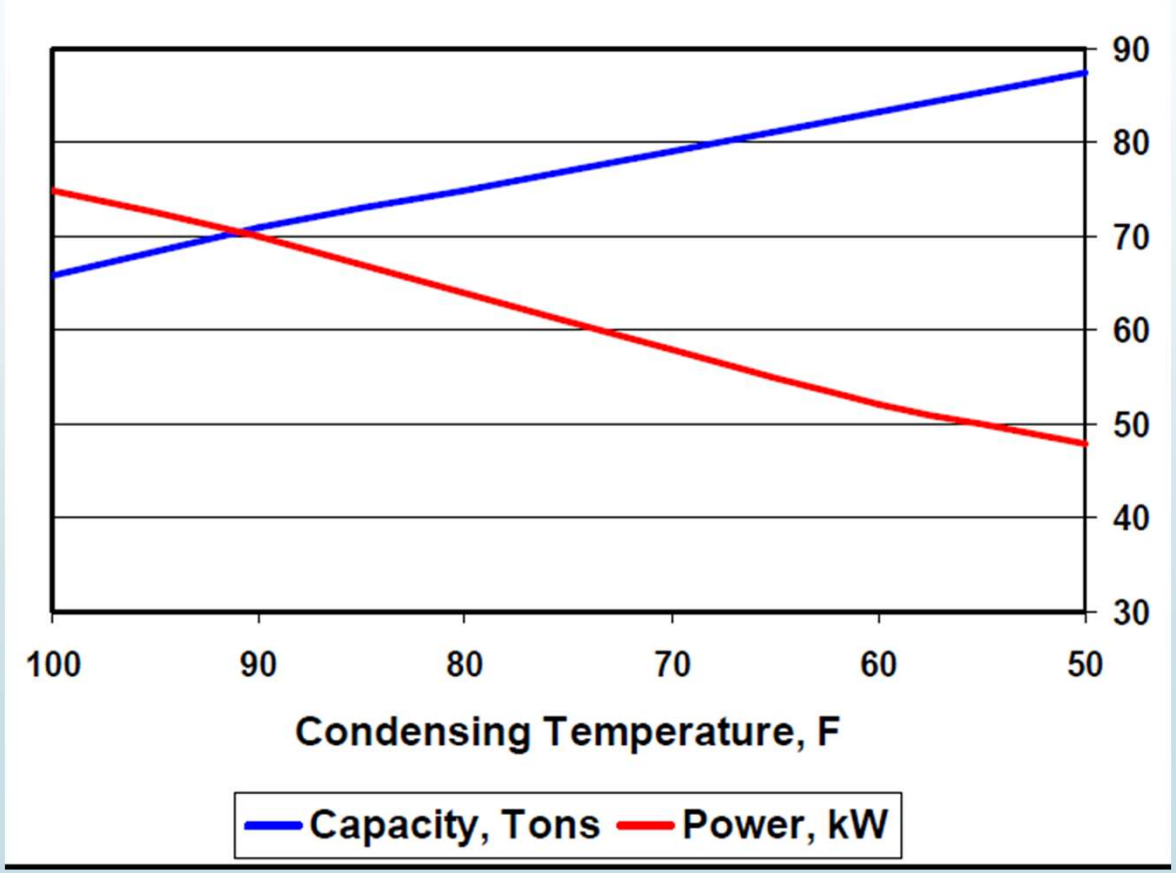


50% capacity
12% power

330 BTUH/Watt

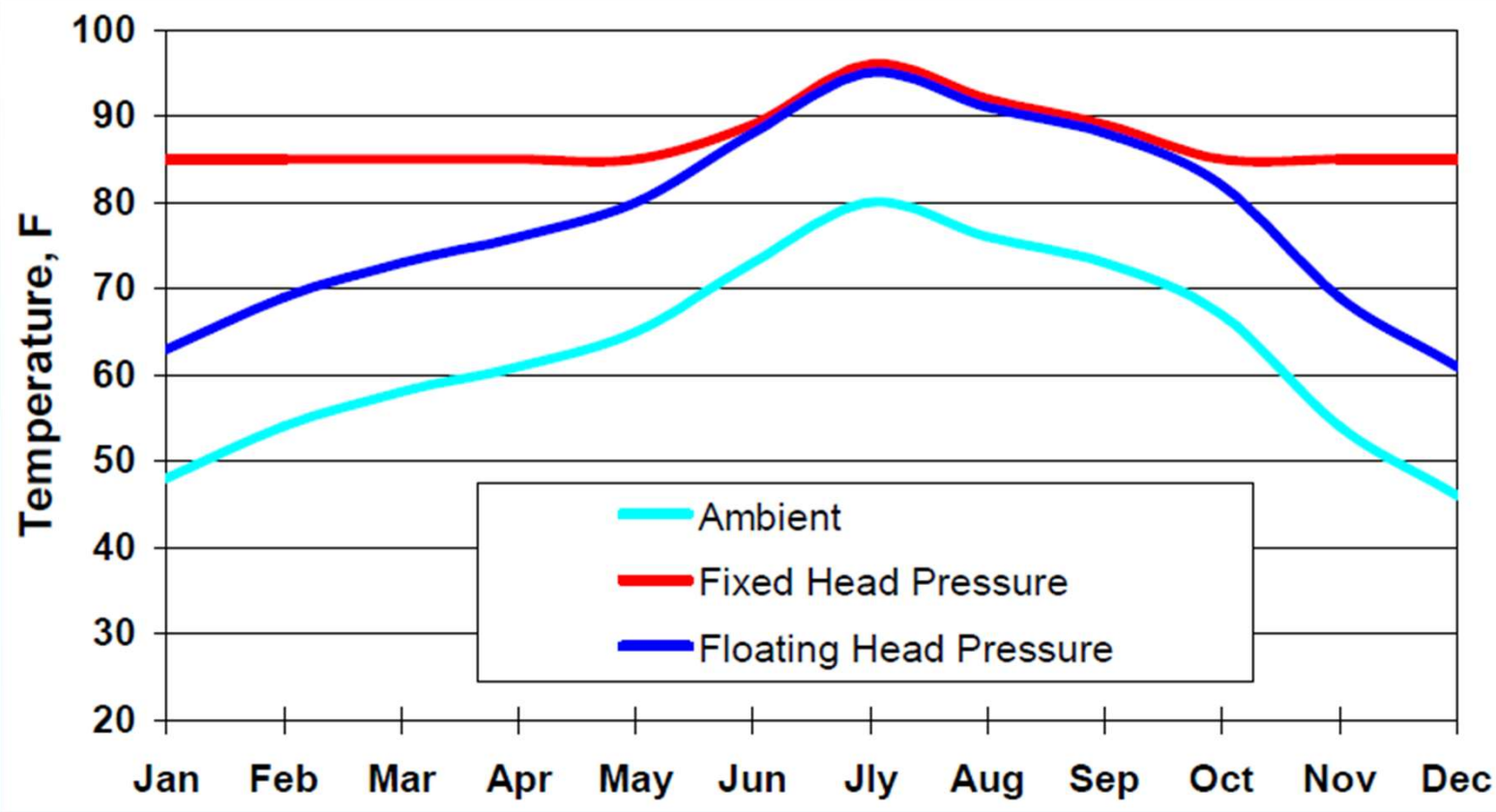
Floating Head Pressure

Impact on capacity and power



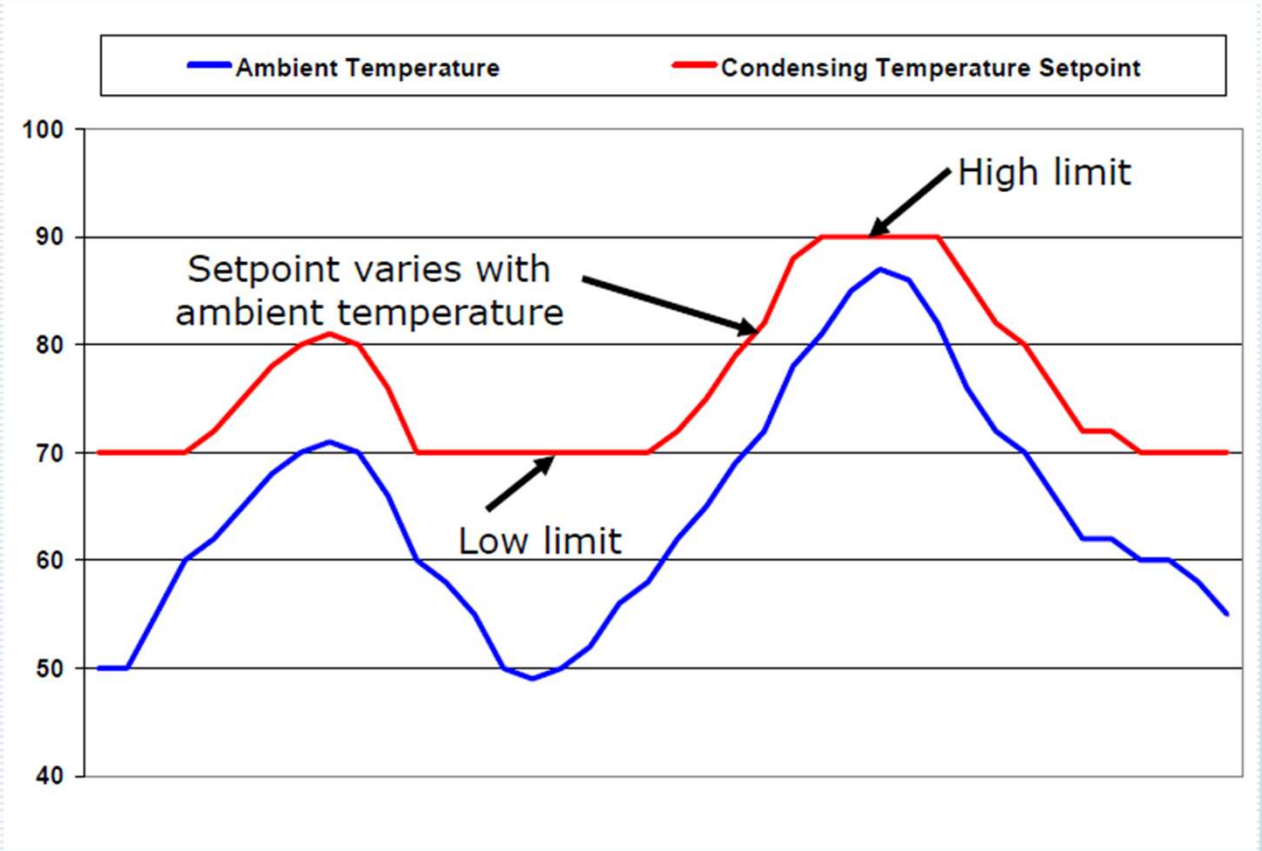
Fixed vs. Floating Head Pressure

Floating cond. temp. according to OAT



Floating Head Pressure

Variable setpoint control



Floating Head Pressure (FHP)

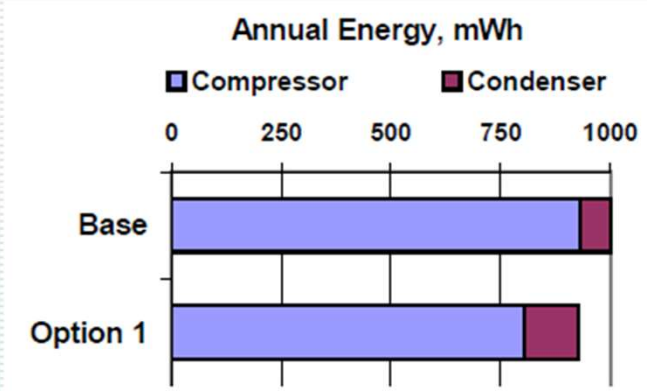
Energy saving potential

- Lower head pressure
- Lower fan power
  - Variable speed
  - Floating setpoint
- Optimum system balance
  - Minimum compressor and fan power
- Savings with optimum FHP
  - 12 – 20% Annual compressor/condenser savings

FHP Case Study

- Cold storage warehouse, in Stockton, California
- Evaporative condenser, average efficiency
- Hourly analysis
- Fixed setpoint at 85°
- Analysis options
  - Fixed setpoint
  - Variable setpoint
  - Variable speed
  - Variable speed with variable setpoint

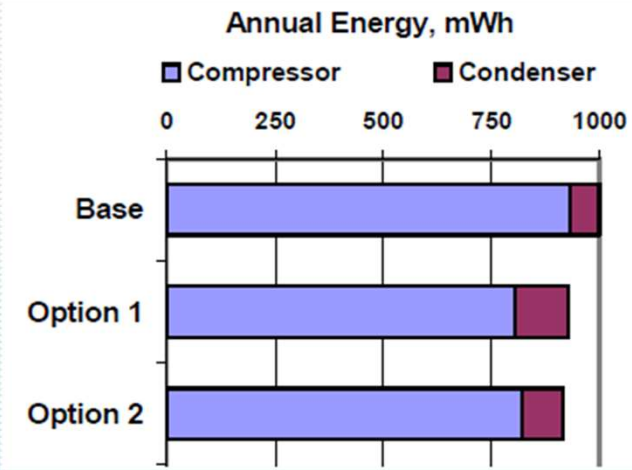
Results – Fixed Setpoint



Control Options						
FHP	FSP	VSP	VFD	Savings	Payback	NPV
X	X			$ 6,400	0.3	$ 63,500

FHP – Fixed head pressure
FSP – Fixed setpoint, float 85° saturated cond. temp.
VSP – Variable setpoint, float setpoint, ambient
VFD – Variable frequency drive

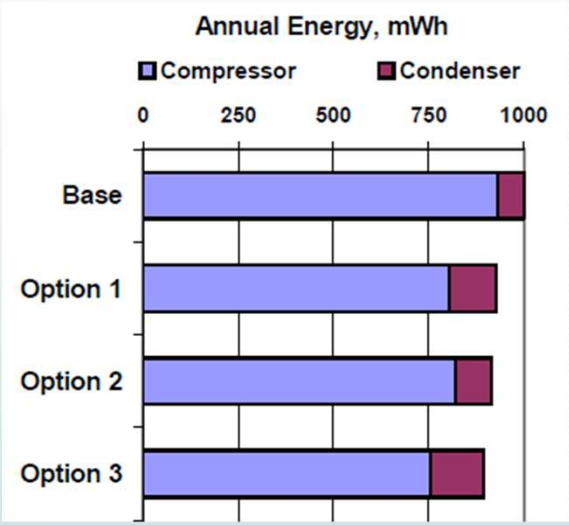
Results – Variable Setpoint



Control Options						
FHP	FSP	VSP	VFD	Savings	Payback	NPV
X	X			$ 6,400	0.3	$ 63,500
X		X		$ 8,400	0.6	$ 80,300

FHP – Fixed head pressure
FSP – Fixed setpoint
VSP – Variable setpoint
VFD – Variable frequency drive

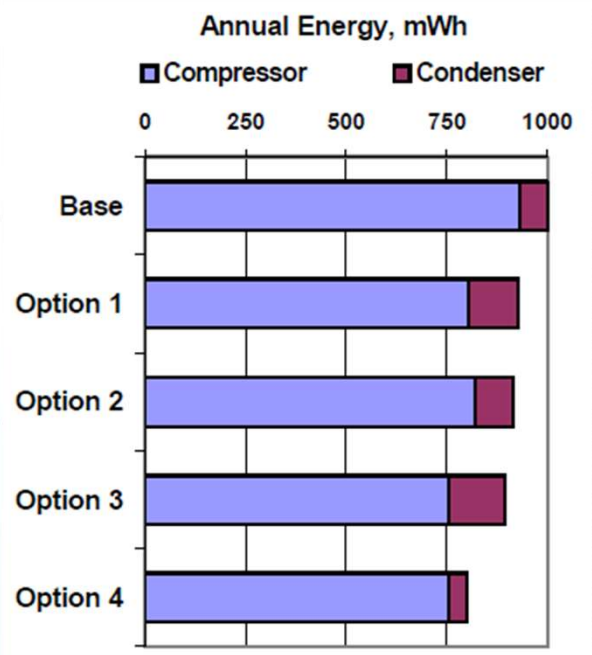
Results – Fixed SP with Variable Speed



Control Options						
FHP	FSP	VSP	VFD	Savings	Payback	NPV
X	X			$ 6,400	0.3	$ 63,500
X		X		$ 8,400	0.6	$ 80,300
X	X		X	$ 9,100	4.4	$ 52,900

FHP – Fixed head pressure
FSP – Fixed setpoint
VSP – Variable setpoint
VFD – Variable frequency drive

Results – Variable SP & Speed



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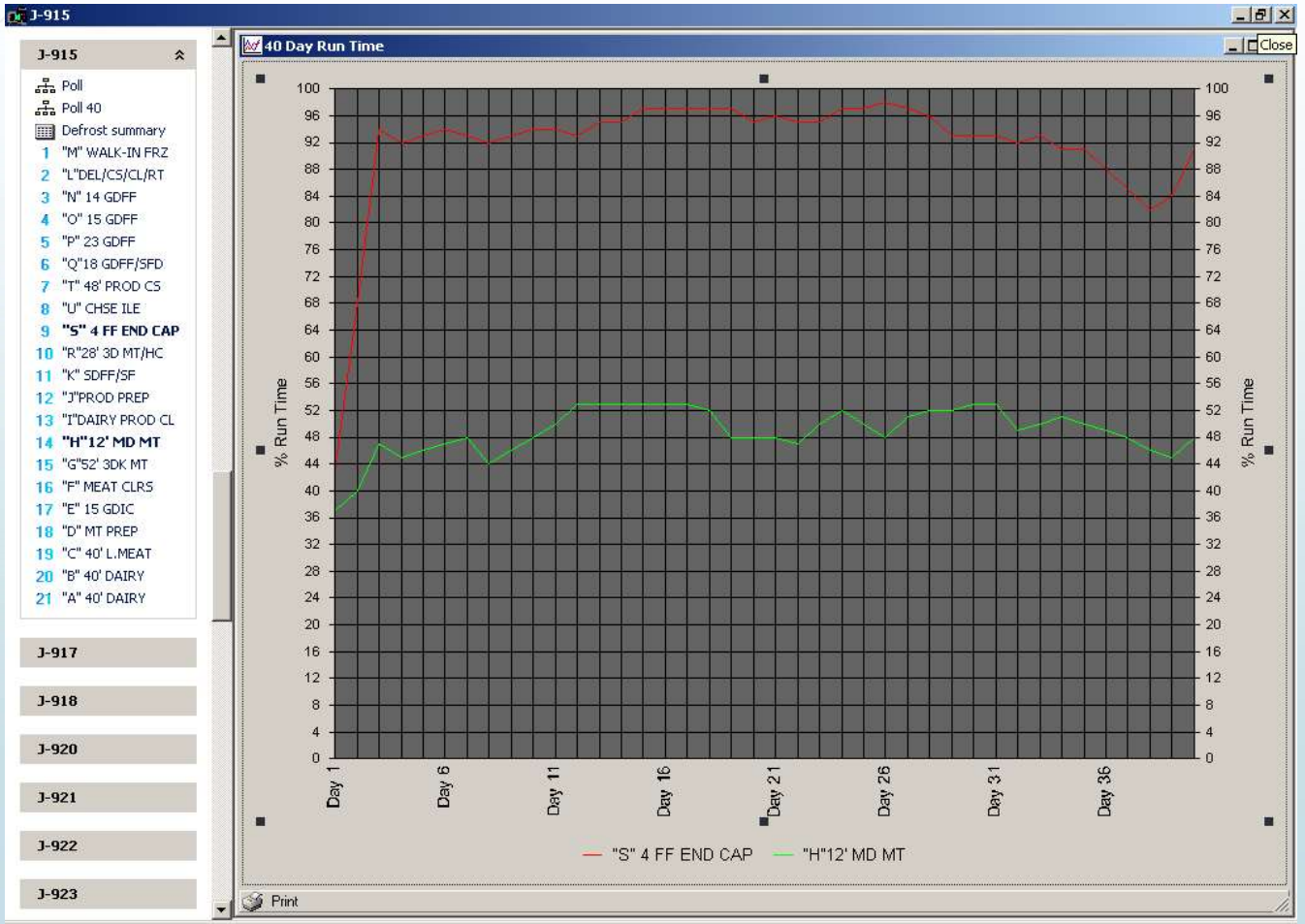
X	X			$ 6,400	0.3	$ 63,500
X		X		$ 8,400	0.6	$ 80,300
X	X		X	$ 9,100	4.4	$ 52,900
X		X	X	$ 21,600	2.1	$175,300

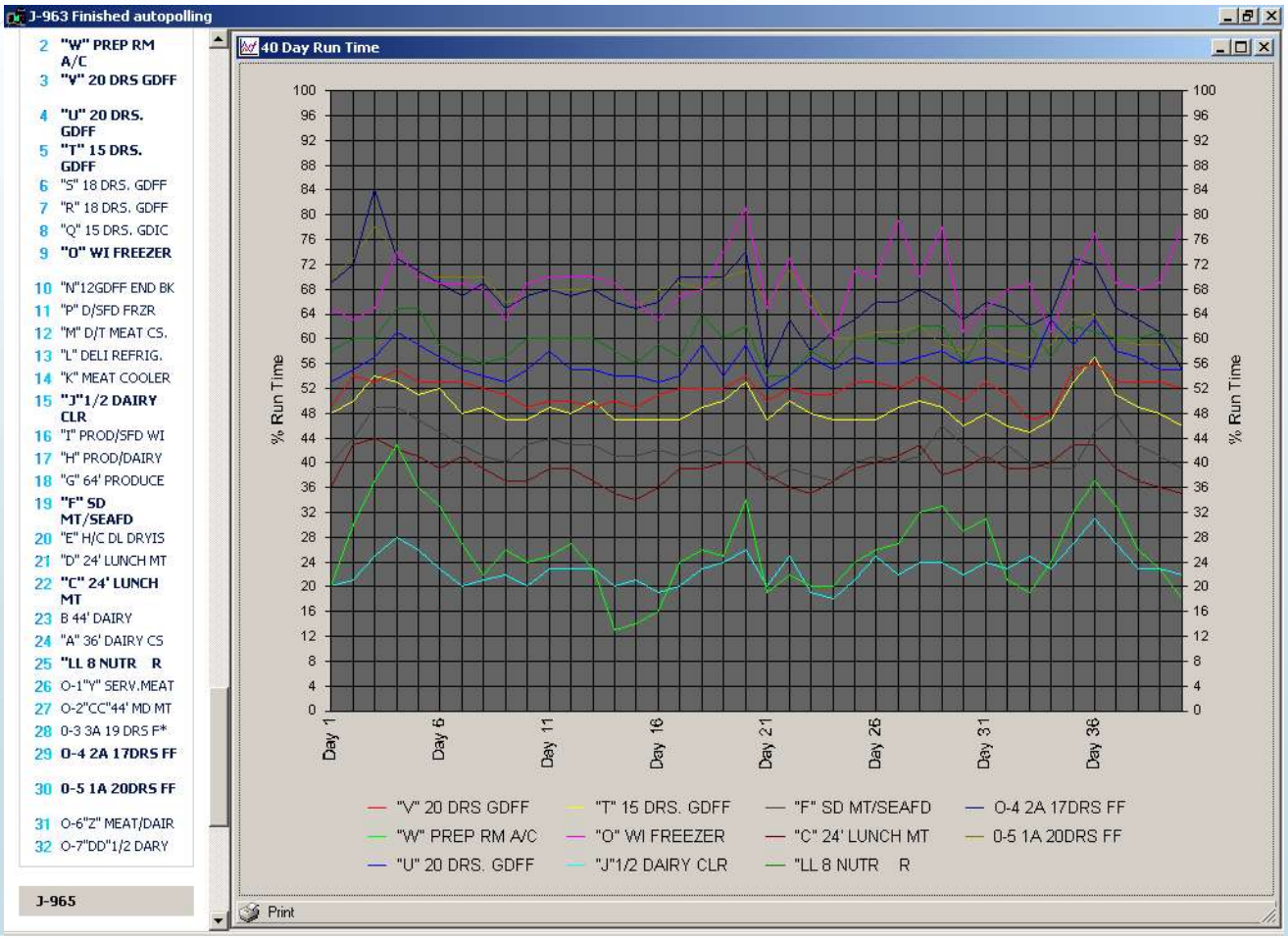
FHP – Fixed head pressure
FSP – Fixed setpoint
VSP – Variable setpoint
VFD – Variable frequency drive

Xprt-1 Settings for Case Type	Case / T1 Temp.	Defrost Number /Fail Safe Min. /Termination °	R12	39 or 401	R22	R502	80 or 402	10 or 408	62 or 404
3 Deck Meat Impact	28	Four / 35 / 48°	30	28	57				72
5 Deck Produce Impact	38/33	Four / 35 / 48°	35	33	66				82
Cheese Case Old Style	34/29	Three / 50 / 48°	32	30	60				76
Cheese Case Impact	34/29	Four / 30 / 48°	32	30	60				76
D/T Case	-5	Two / 60 / 52°			20	27	31	24	29
Dairy Case Old Style	36/31	Four / 50 / 48°	33	31	62				78
Dairy Case Impact	36/31	Four / 40 / 48°	33	31	62				78
Dairy WI	36	Two / 60 / 48°	33	31	62				78
Deli Refrigeration/Beer	37/32	Three / 50 / 48°	35	33	65				81
Deli WI Freezer	-5	Four / 35			20	27	31	24	29
Floral	40/35	Two / 60 / 48°	38	37	70				87
GDFF Old Style	-2	One / 75 / 52°			21	29	34	27	32
GDFF Impact	-2	One / 40 / 48°			21	29	34	27	32
GDIC Old Style	-7	One / 75 / 52°			19	25	29	23	27
GDIC Impact	-7	One / 40 / 48°			19	25	29	23	27
Juice/Beverage/Nutrition	36/31	Four / 40 / 48°	33	31	62				78
Lunch Meat Old Style	34/29	Four / 50 / 48°	32	30	60				76
Lunch Meat Impact	34/29	Three / 35 / 48°	32	30	60				76
Meat A/C	55	One / 120 / 70°	52	52	93				115
Meat WI	31	Two / 45 / 48°	29	27	56				71
Produce A/C	60	One / 120 / 70°	58	58	102				125
Produce Case Old Style	38/33	Two / 60 / 48°	35	33	66				82
Produce Island Impact	38/33	Four / 45 / 48°	35	33	66				82
Produce Green Impact	38/33	Four / 30 / 48°	35	33	66				82
Produce WI	37	One / 60 / 48°	34	32	65				81
Retarder	37	Two / 60 / 48 °	34	32	65				81
SD Meat (Fresh)	25	Three / 50 / 48°	24	22	49				62
SD Seafood	31/26	Three / 50 / 48°	29	27	56				71
SDFF	-5	Two / 60 / 52°			20	27	31	24	29
Service Meat R3 Impact	28	Four / 40 / 48°							
Service Meat	31	One / 110	29	27	56				71
Self Service 3 Dk Meat	28	Four / 30 / 48°	30	28	57				72
WI Freezer	-9	Two / 35			18	23	27	21	25
Temperature control lower the CI 5# and change timing to 4 minute cycle on, center temp. 1° above and 1° below T1 setpoint.									
Enable the thermostat			R12	39 or 401	R22	R502	80 or 402	10 or 408	62 or 404
Condensing Med Temp	70°	Cut-in / Cut-out	90/70	105/85	141/121				168/148
Condensing Low Temp	65°	Cut-in / Cut-out	85/65	100/80	131/111	145/125	170/150	145/125	156/136
Condensing Gas Defrost	80°	Cut-in / Cut-out			164/144	192/172	210/190	180/160	194/174
Shift for reclaim Center on	95°	Cut-in / Cut-out	120/100	140/120	190/170	210/190	240/220	210/190	230/210
Throttle or Range	20#								
Defrost Termination	42°		39	40	72	84	95	81	89
Defrost Termination	48°		44	50	80	94	107	91	99
Defrost Termination	52°		48	65	87	101	120	98	109
Rack Settings									
Suction Group Set Point			R12	39 or 401	R22	R502	80 or 402	10 or 408	62 or 404
Dead Band 0.2	+22°/+16°			19 / 17	44 / 40		62 / 57	51 / 46	57 / 53
	-14°/-22°				12 / 10		21 / 18	16 / 13	20 / 17
A8 settings	10°	Below condensing setpoint							
A9 settings	4#	Below A8 settings							
Hot water Reclaim	130°-126°	Altech / CPC	Temp	Alarms	10°	above	set point	for 90 min	
Hot water Gas	125°-120°	E1 / E2	Temp	Alarms	10°	above	set point	for 60 min	
9/21/2006									

Optimize Setpoints



Optimize Setpoints



Variable Air Volume at the Evaporator

- Vary the fan speed in the cooler
  - Reduce speed and float suction up
- Cycle fans with the temp control
  - All or part of the fans to keep stratification from occurring
- Savings from:
  - Reduced fan energy
  - Reduced cooling load

Variable Air Volume Study Case

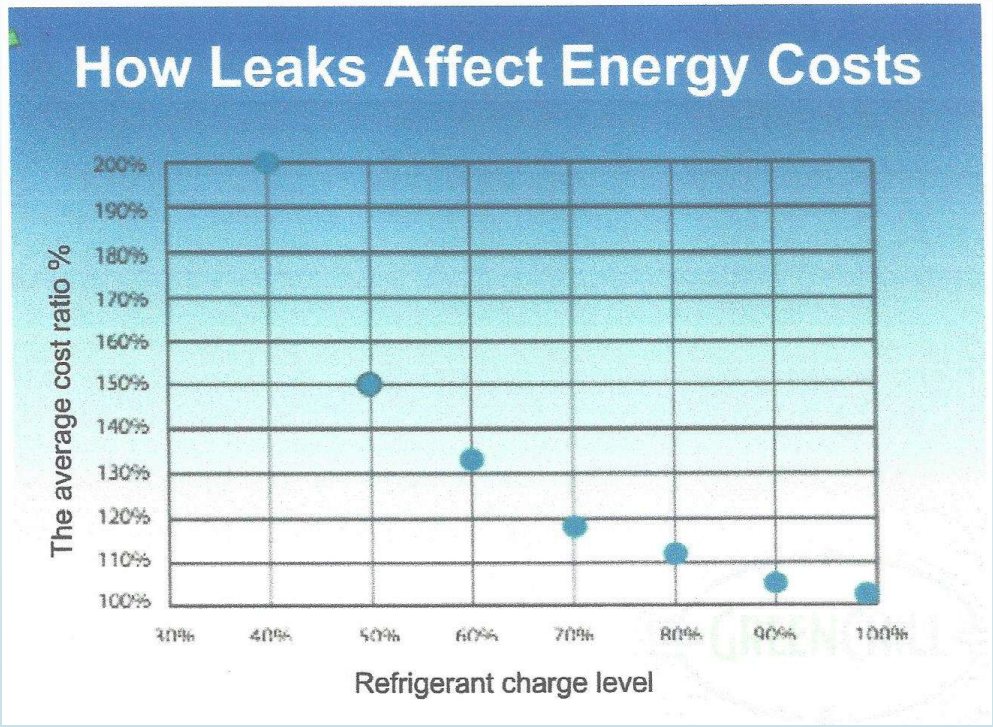
50,000 Square foot freezer

		Design	Part Load (50%)	
		Full Speed	Full Speed	70% Speed
Air Flow Rate (CFM/Ton)		1,852	3,017	2,385
Fan Power (Watts/Ton)		359	652	281
Cost ($/Ton-Hour)	Fan	$ 0.040	$ 0.080	$ 0.031
	Compressor	$ 0.167	$ 0.184	$ 0.163
	Total	$ 0.207	$ 0.264	$ 0.194
% Change from Design			28%	-7%
% Change from Part Load, Full Speed to Variable Speed				-27%
Annual Energy (KWh)	Fan		700,800	267,522
	Compressor		1,612,979	1,428,131
	Total		2,313,779	1,695,653
Annual Energy Cost (at $.10/kWh)		-	$ 231,378	$ 169,565
Annual Savings				$ 61,813
Savings per Cu. Ft.				$ 0.04

Utility Presented $39,000 incentive to Grocer

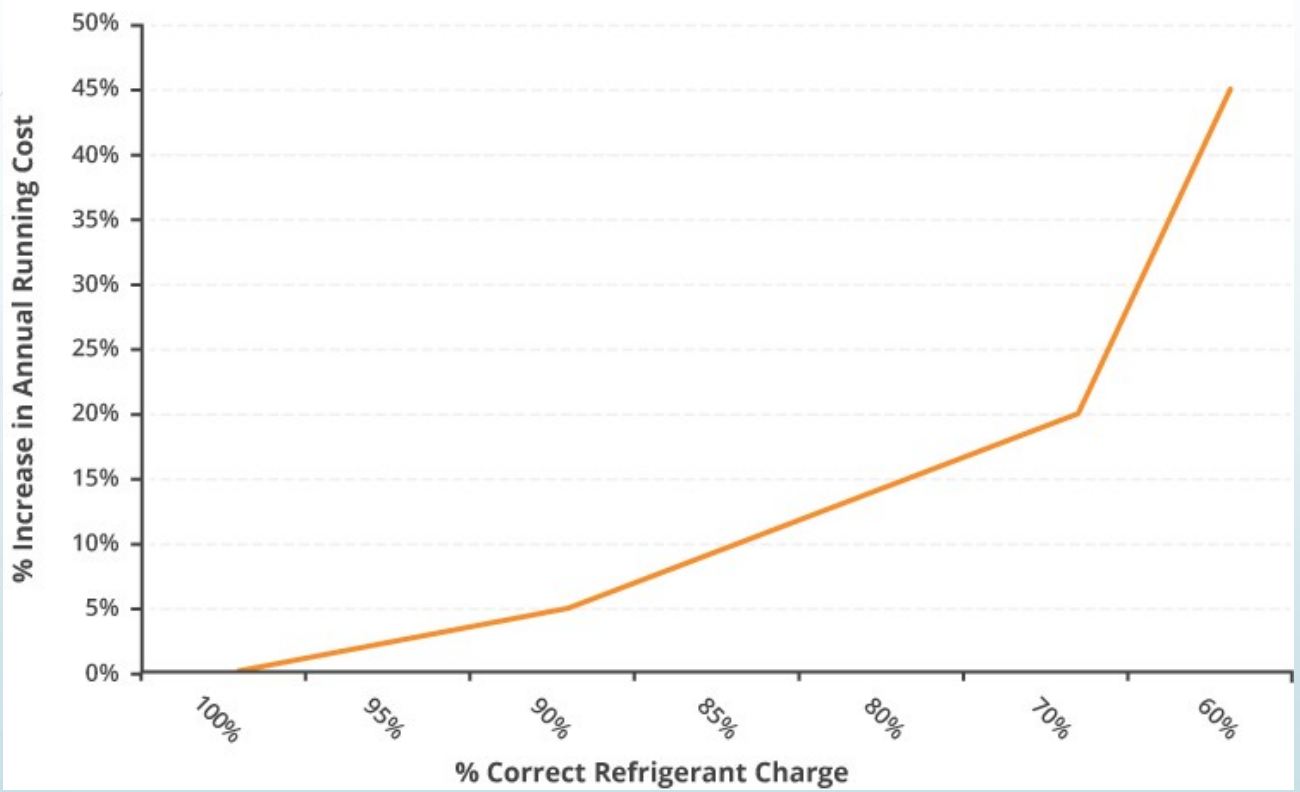
- Utility company presented grocer with a check for $39,607 for saving close to 900,000 kilowatt hours per year by upgrading their refrigeration control and energy management systems at their cold storage distribution center.
- The refrigeration project, which included the cycling of evaporator fans, floating head pressure and floating suction controls to help reduce energy usage.

Refrigerant Level Charge



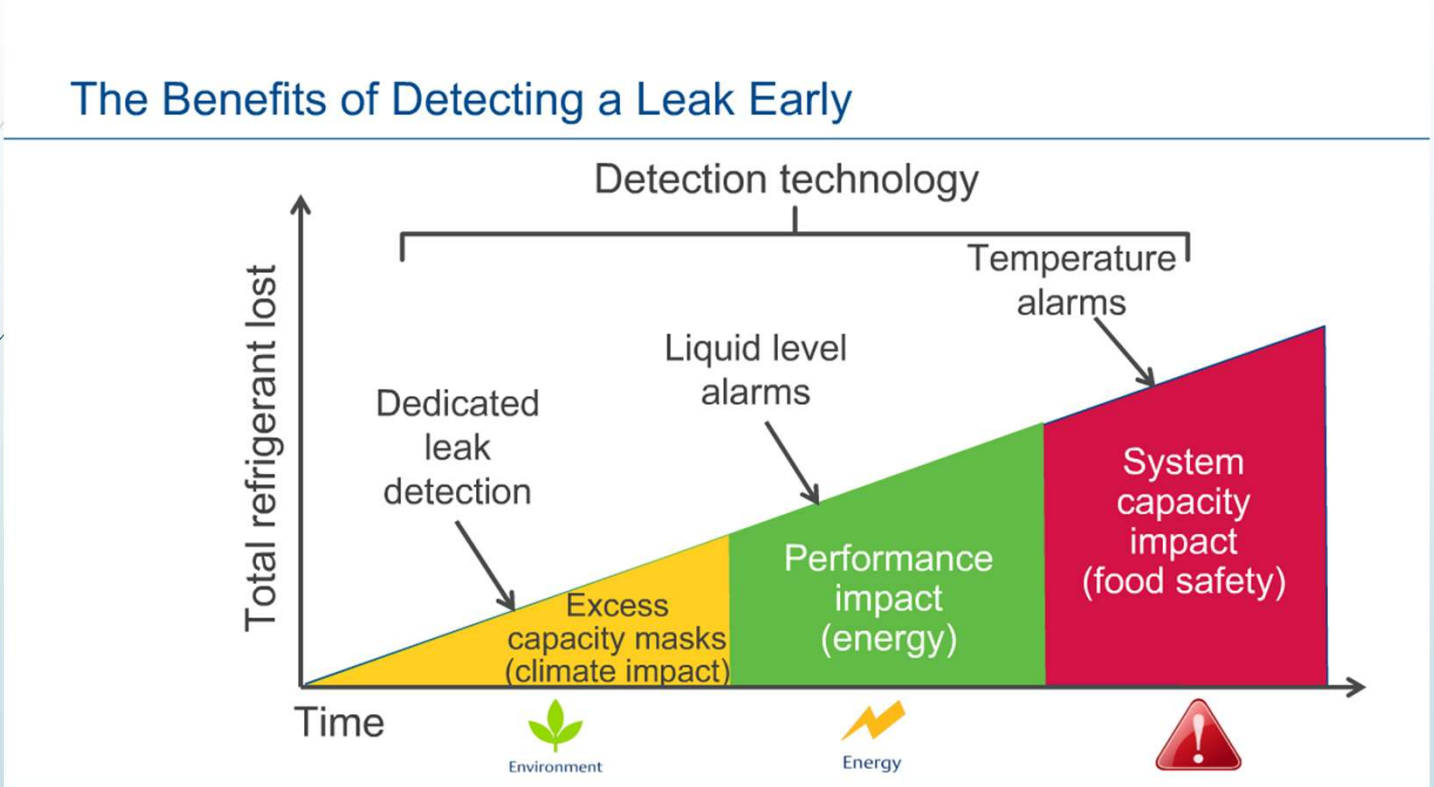
*Data from Impacts of Refrigerant Charge on Air Conditioner and Heat Pump Performance, Purdue University 2010

Refrigerant Level Charge – Runtime Penalty



*Bostock, David. "Refrigerant Loss, System Efficiency and Reliability – A Global Perspective." Institute of Refrigeration Annual Conference 2013.

Refrigerant Level Charge

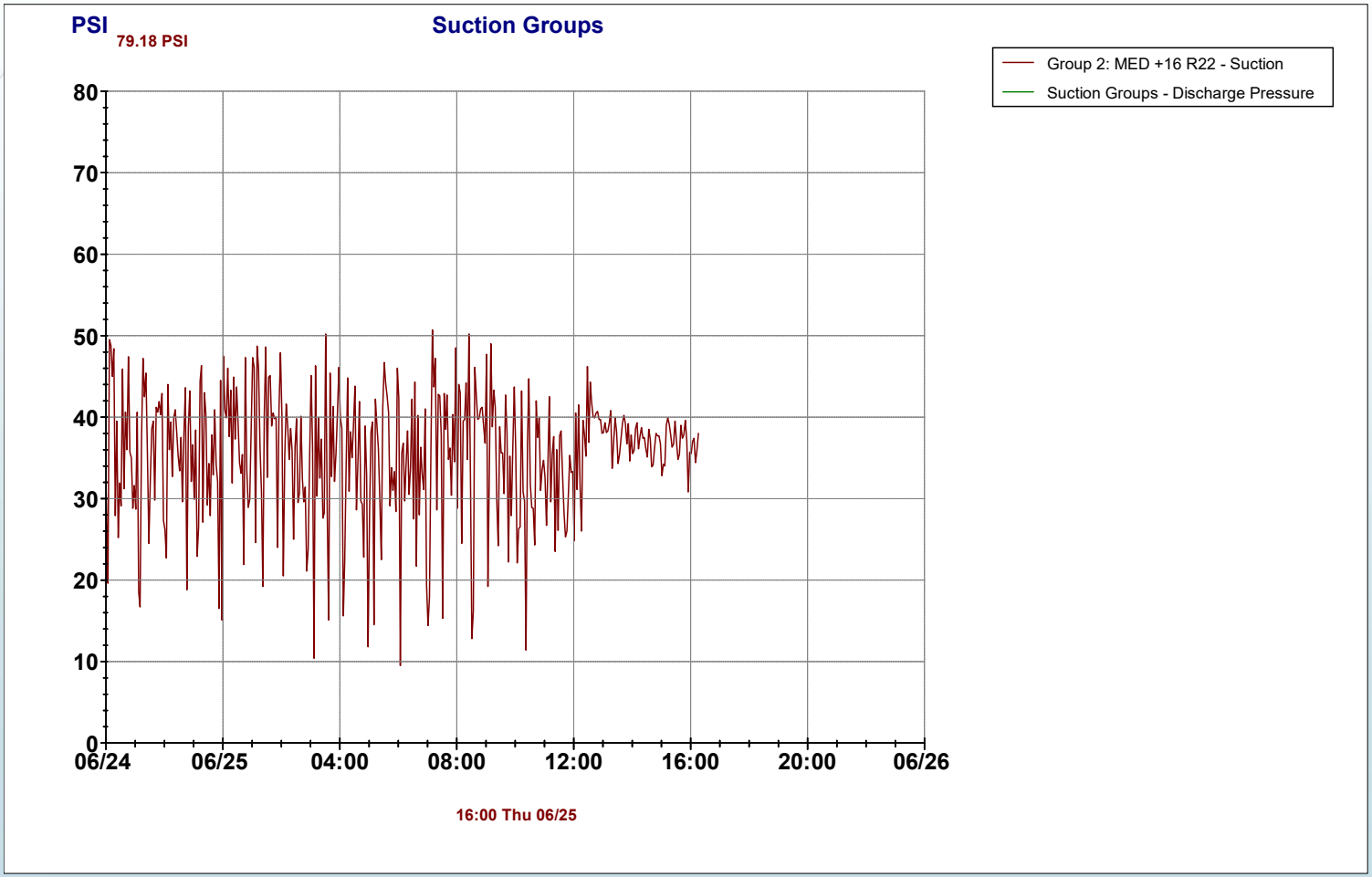


Refrigerant Level Charge

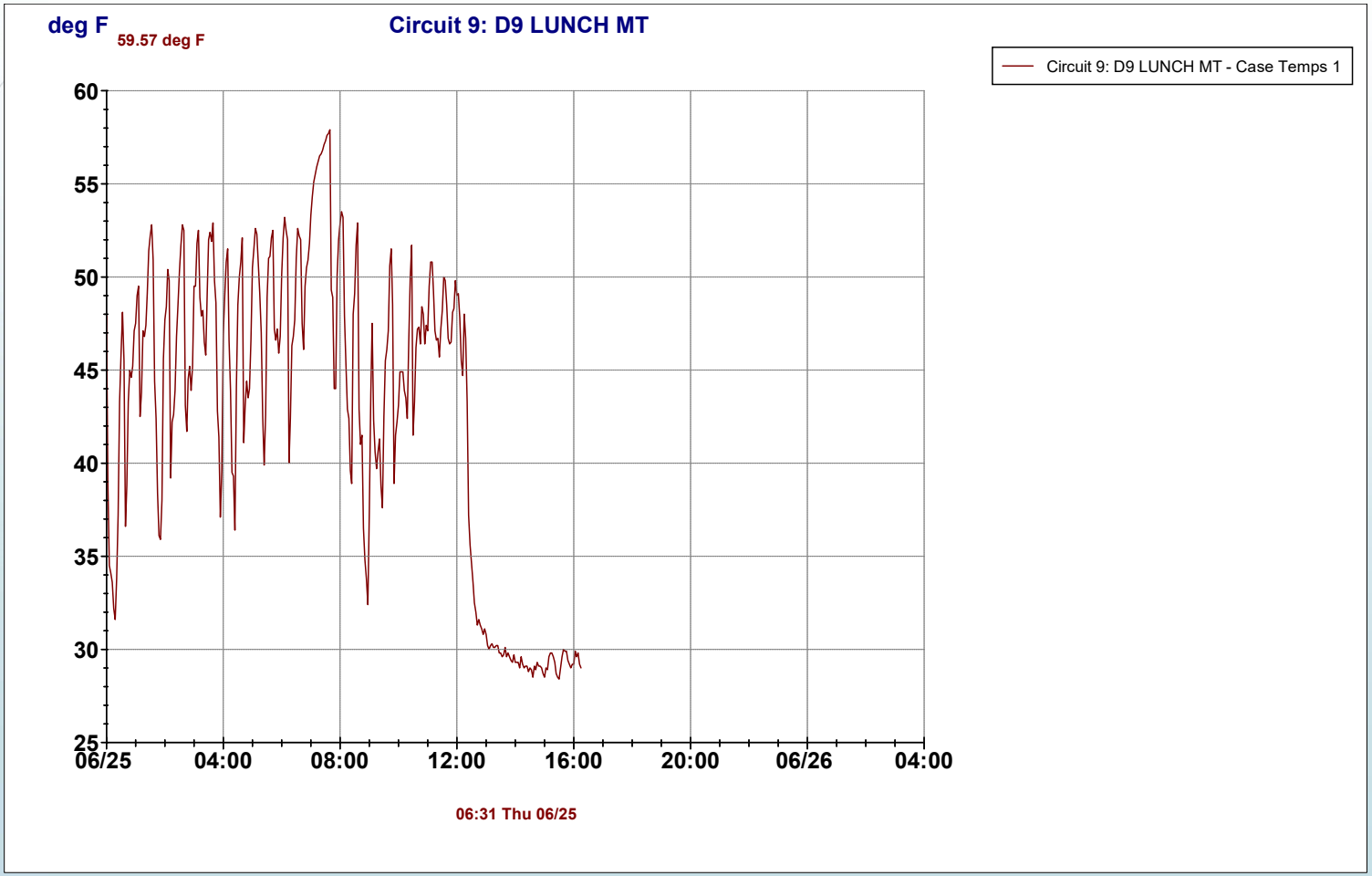
1) Cost to Replace Leaked Refrigerant		
1. Refrigerant type:	R-404A	click inside the yellow box and select the refrigerant from the drop-down menu
2. Amount of refrigerant leaked (in pounds):	100	type number of pounds in yellow box
3. Price per pound that you pay for refrigerant:	$6.83	for $7.00, type in 7.00
Cost to replace leaked refrigerant:	*$683*	

2) Sales/Profit		
1. Item to be sold (milk, frozen peas, hotdogs, etc.)	milk	type the name of the product in the yellow space
2. Units (gallons, pounds, packs, ounces, etc.)	gallons	type the unit of the product in the yellow space
3. Sales price per unit	$3.50	for $3.50, type in 3.50
4. Profit margin per unit sold (in percent):	1.00	for 1%, type in 1; for 2.03%, type in 2.03
You have to sell	*19,514*	*gallons of milk*
to pay the replacement cost of	*100*	*pounds of refrigerant*

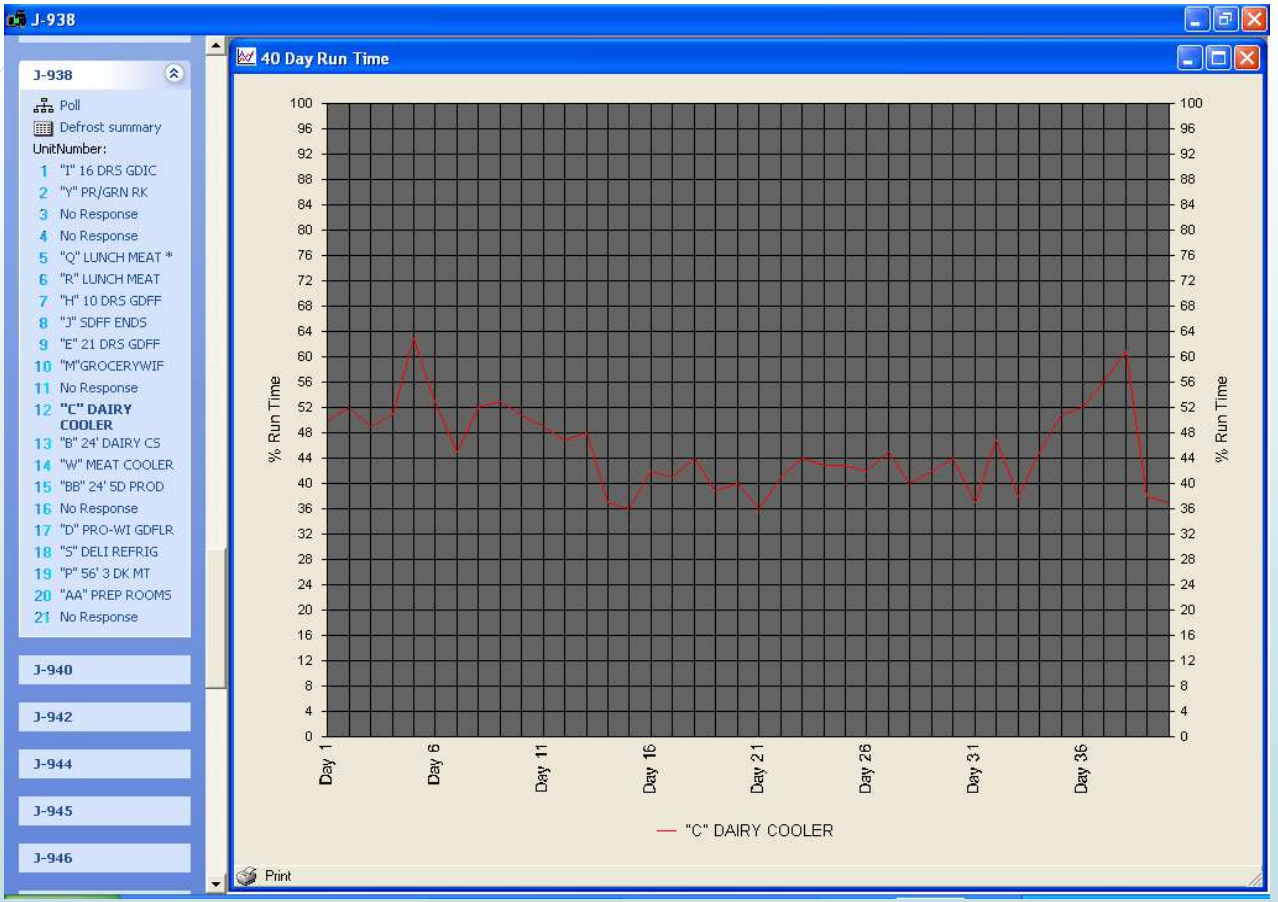
Refrigerant Level Charge - Suction



Refrigerant Level Charge - Temperature



Maintenance and Energy Efficiency



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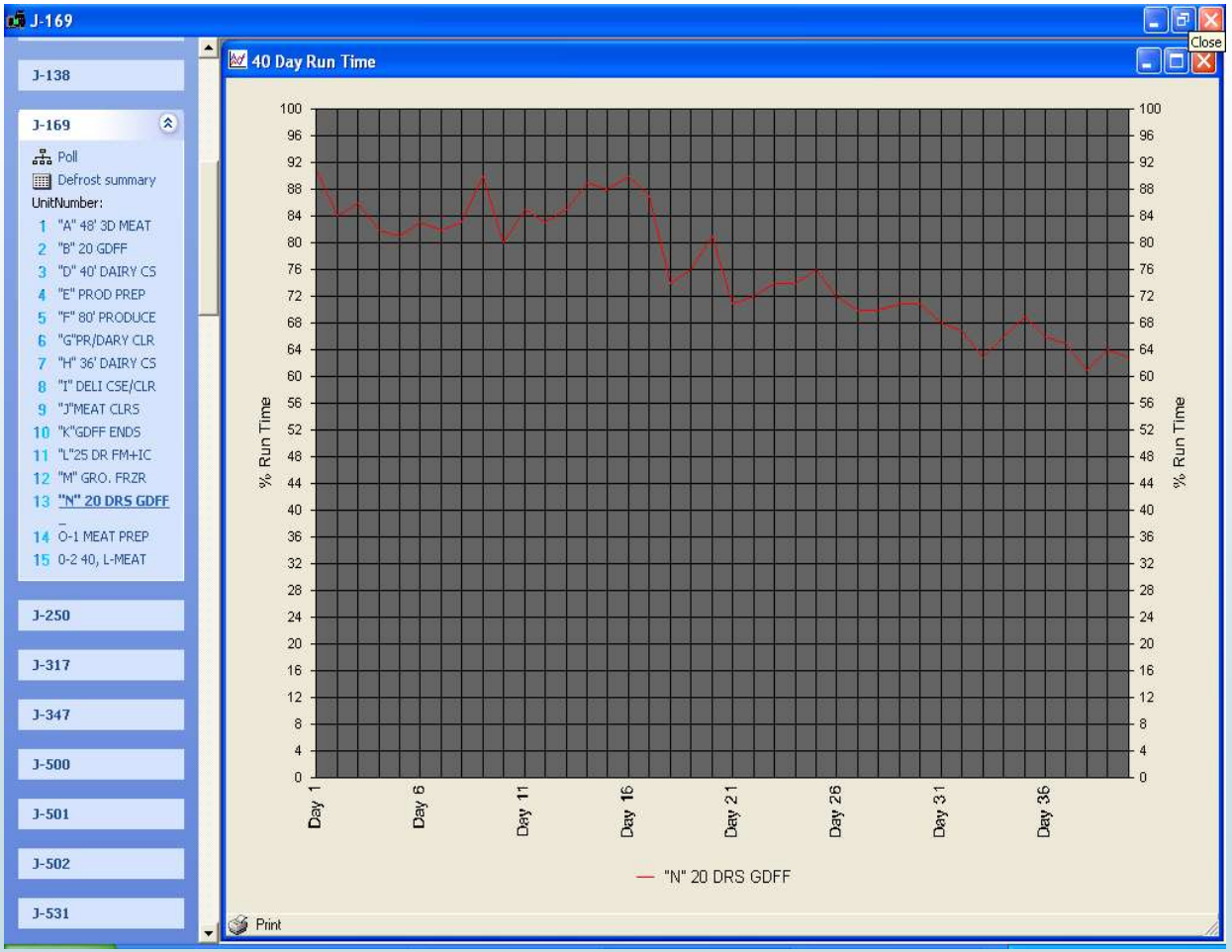

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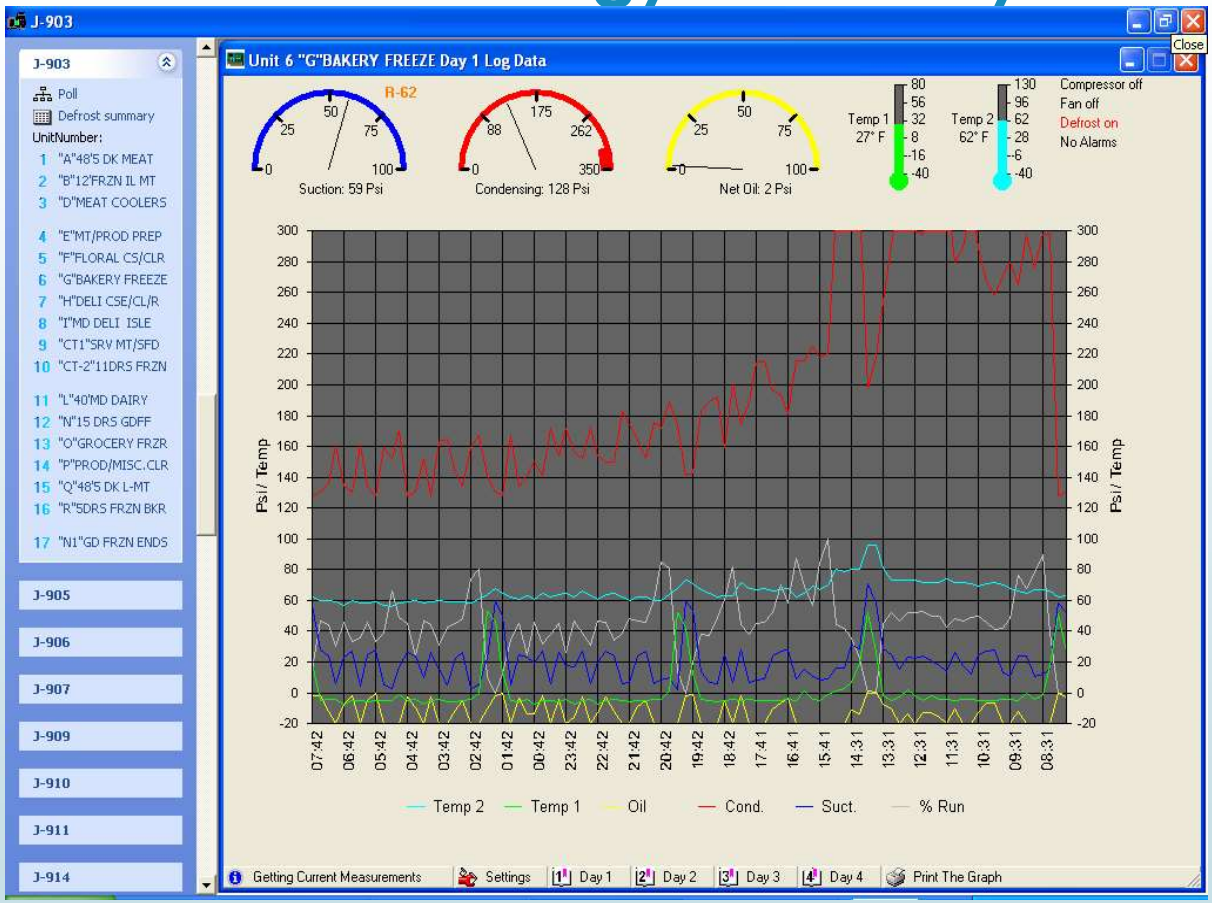

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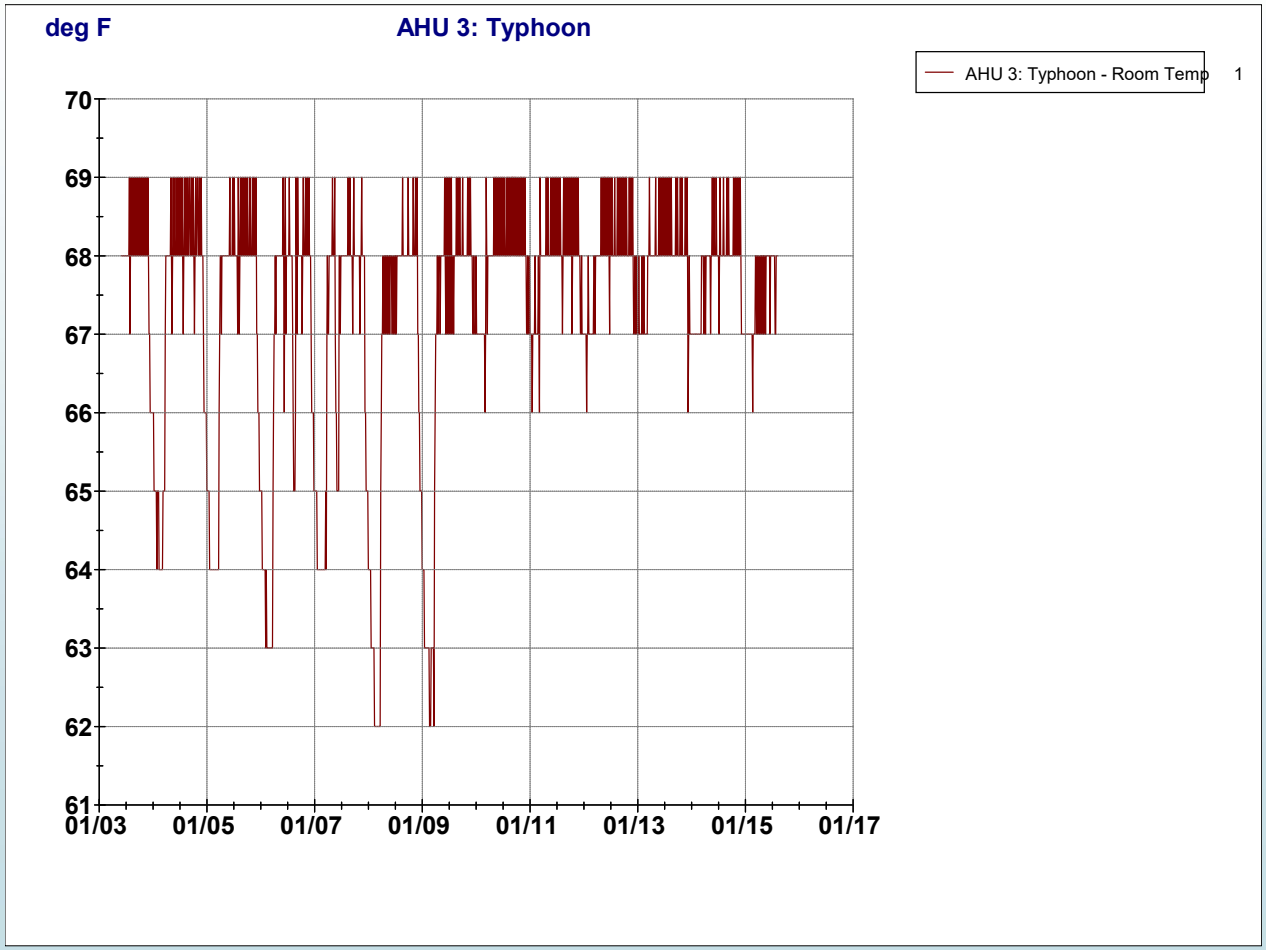

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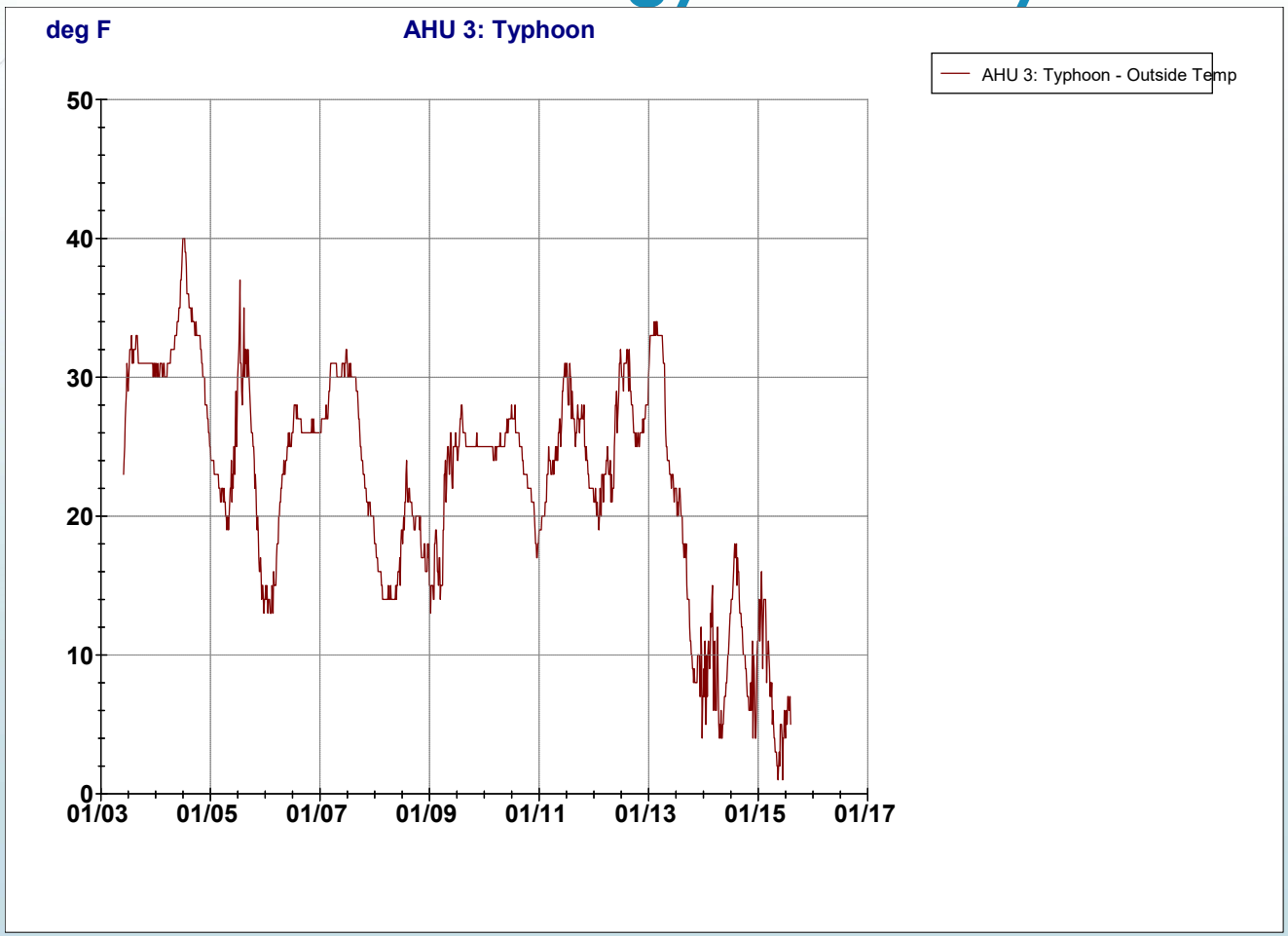
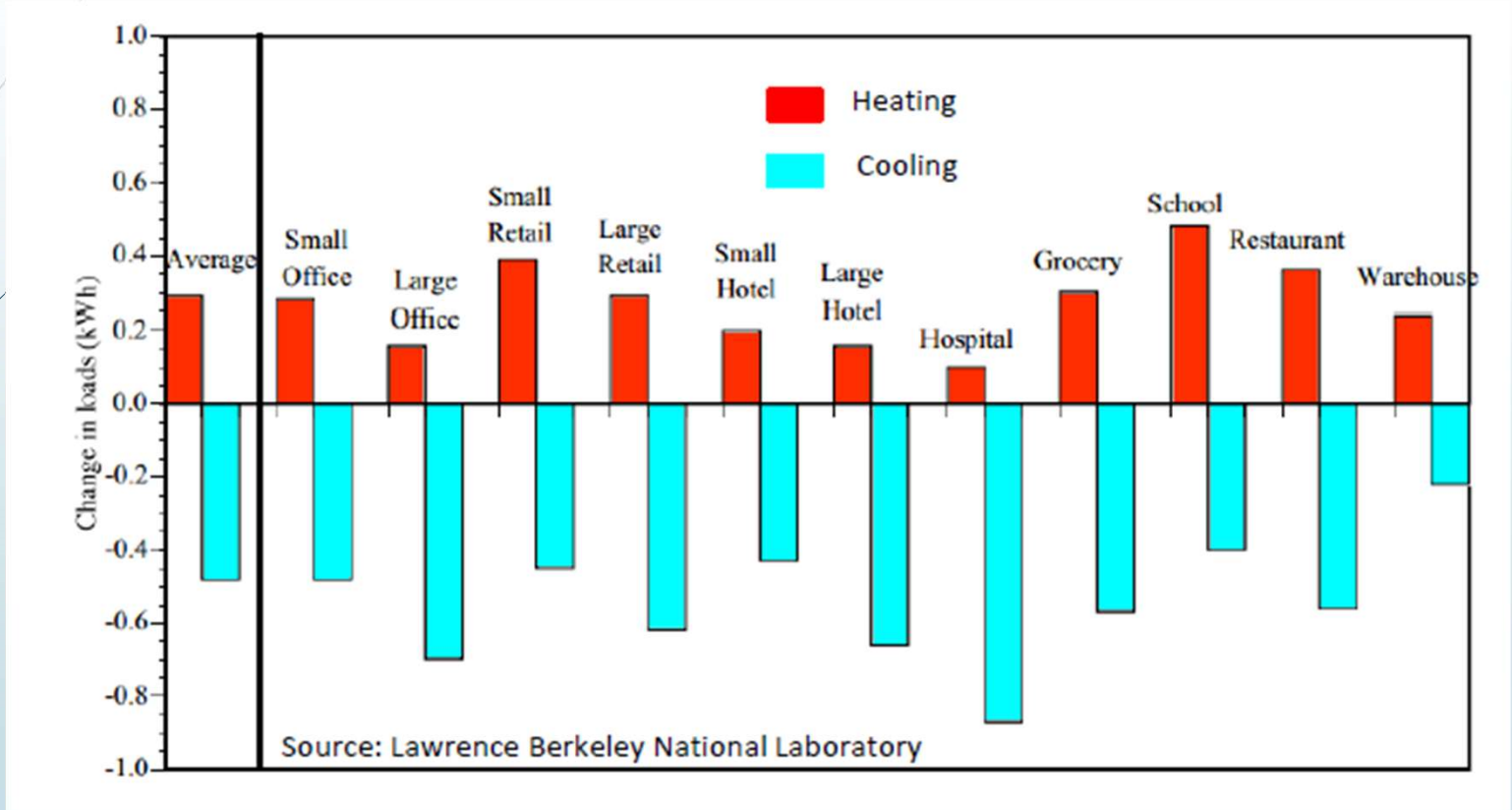
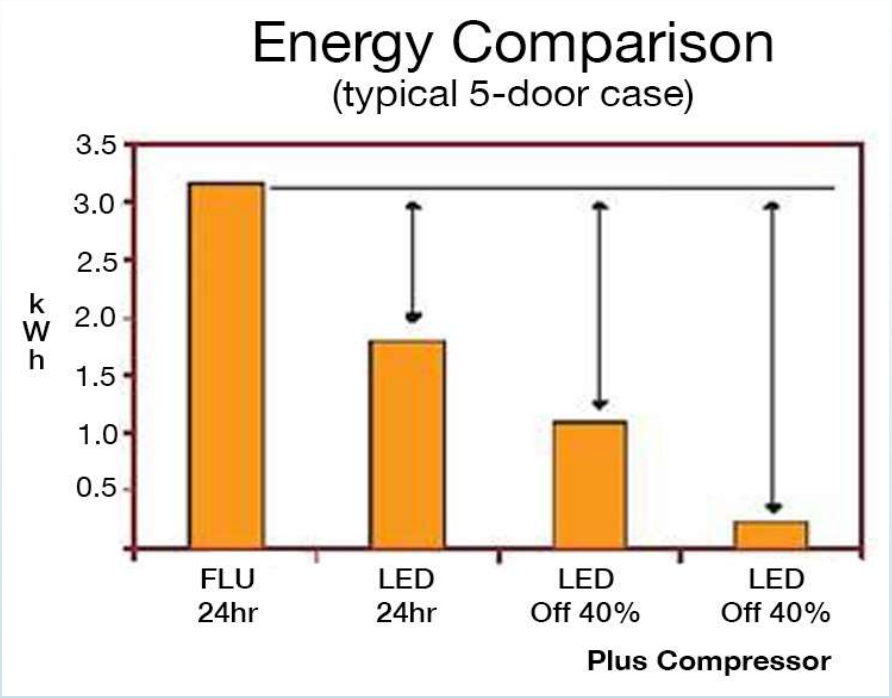
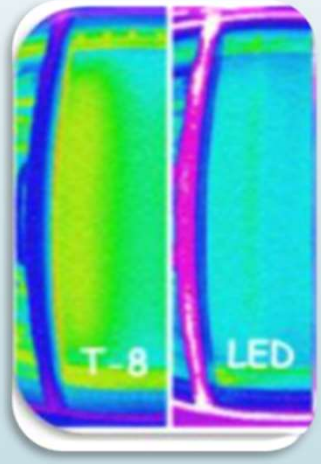


Effects of Lighting Reduction on HVAC



LED Light Savings





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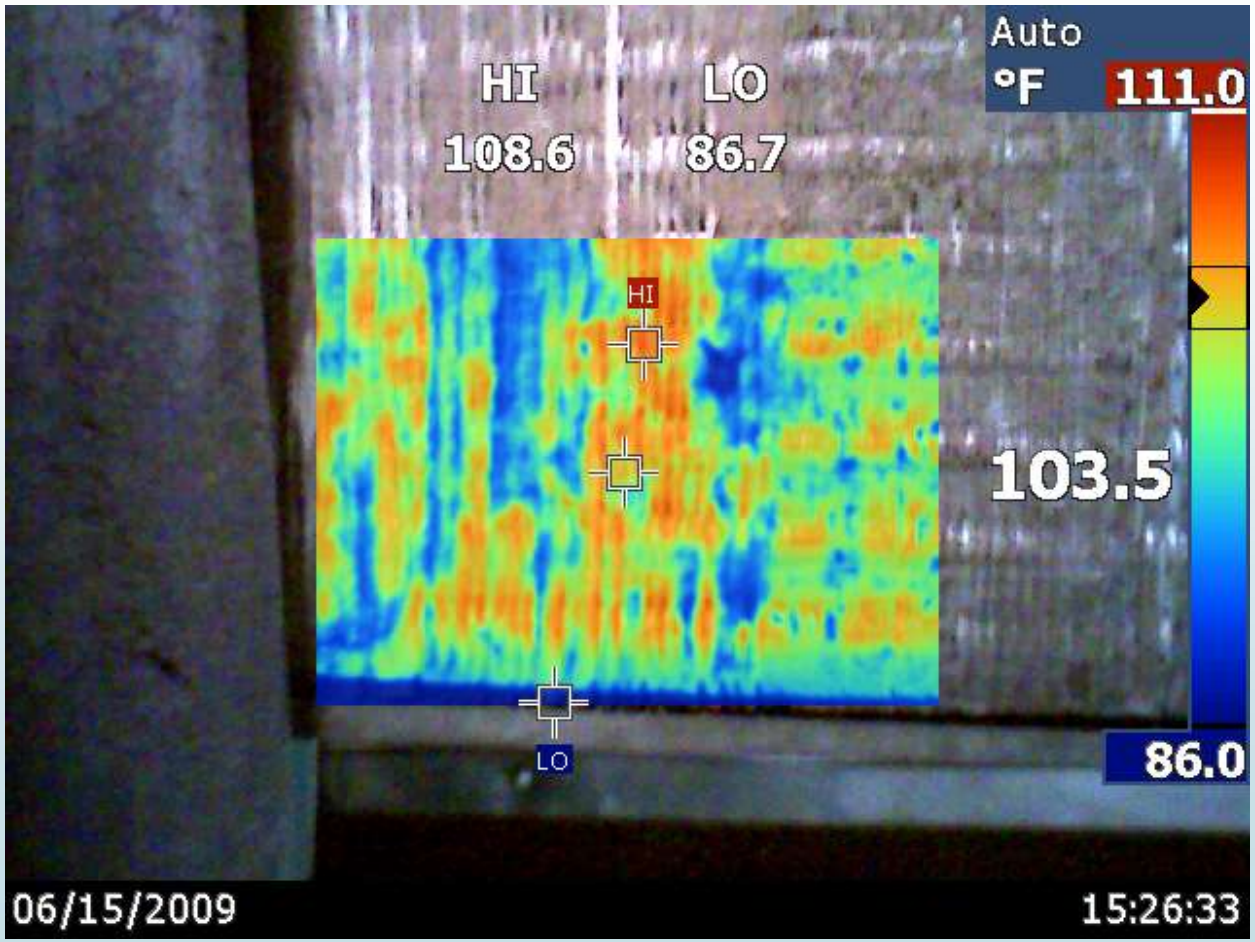

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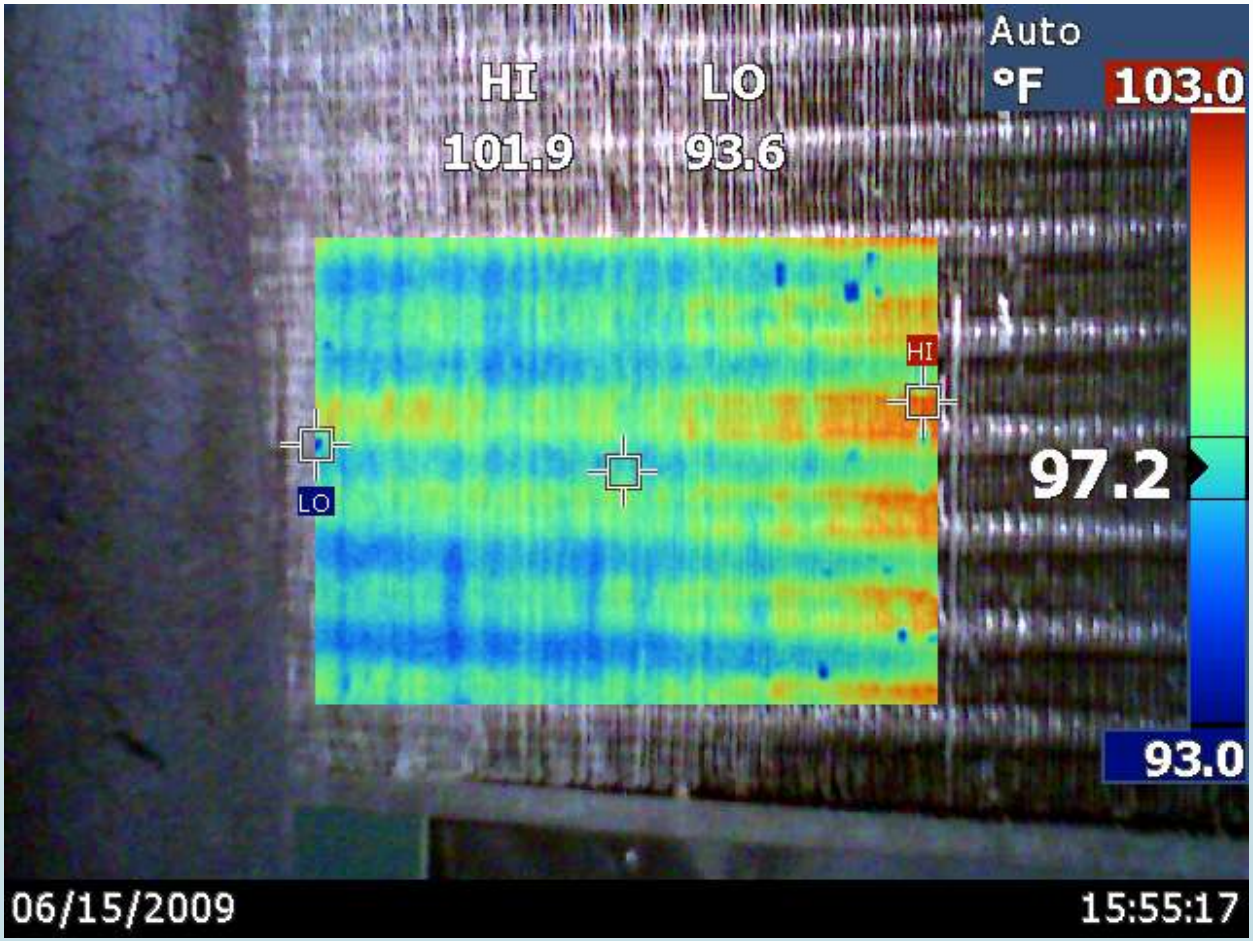
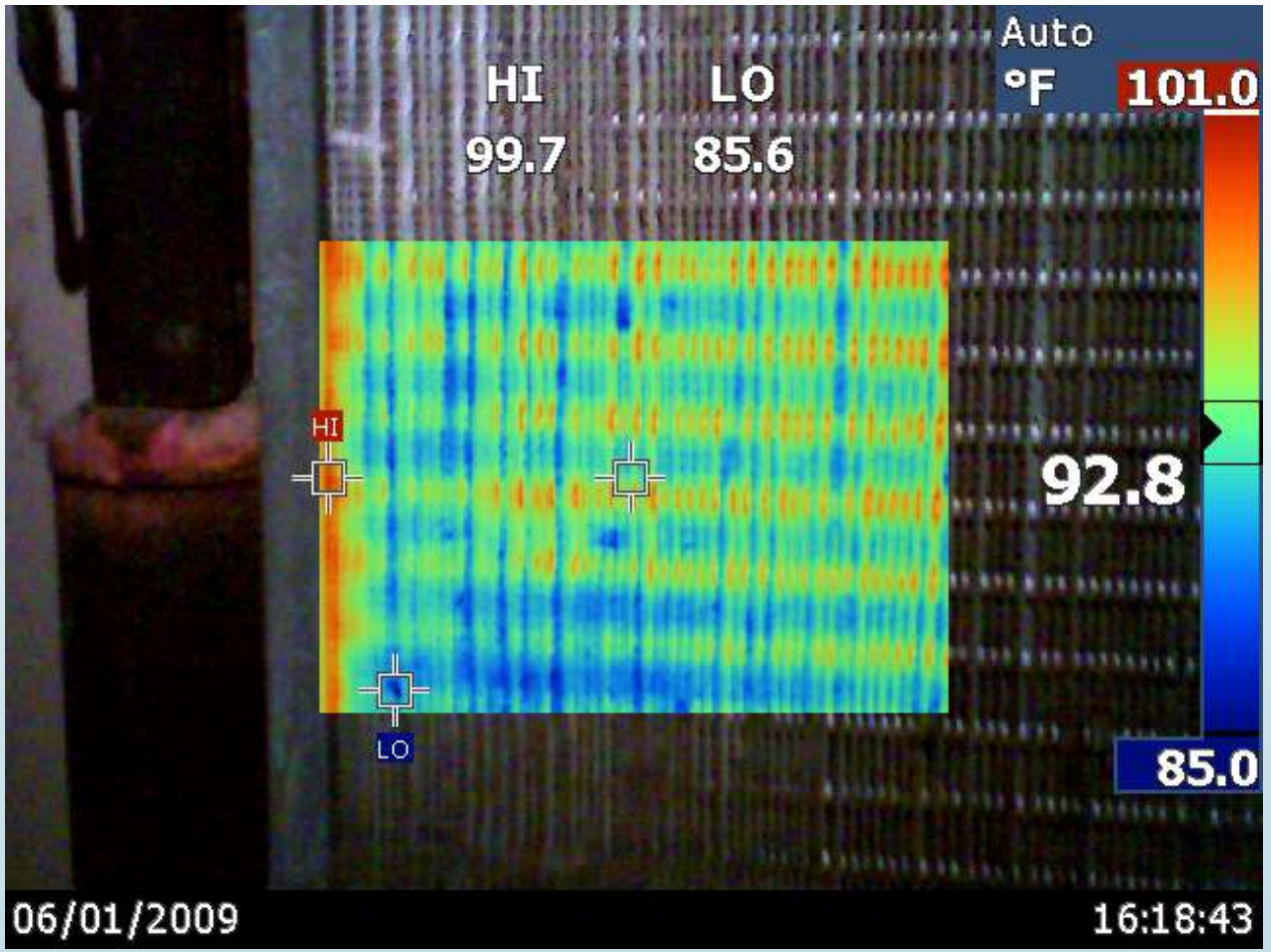


Coil Cleaning

- Reduced electrical usage
- Reduced service calls
- Prolonged equipment life
- Electric savings of 46 – 50%
  - *Source Cool Savings Project – FSTC and the City of San Francisco

Maintenance and Energy Efficiency



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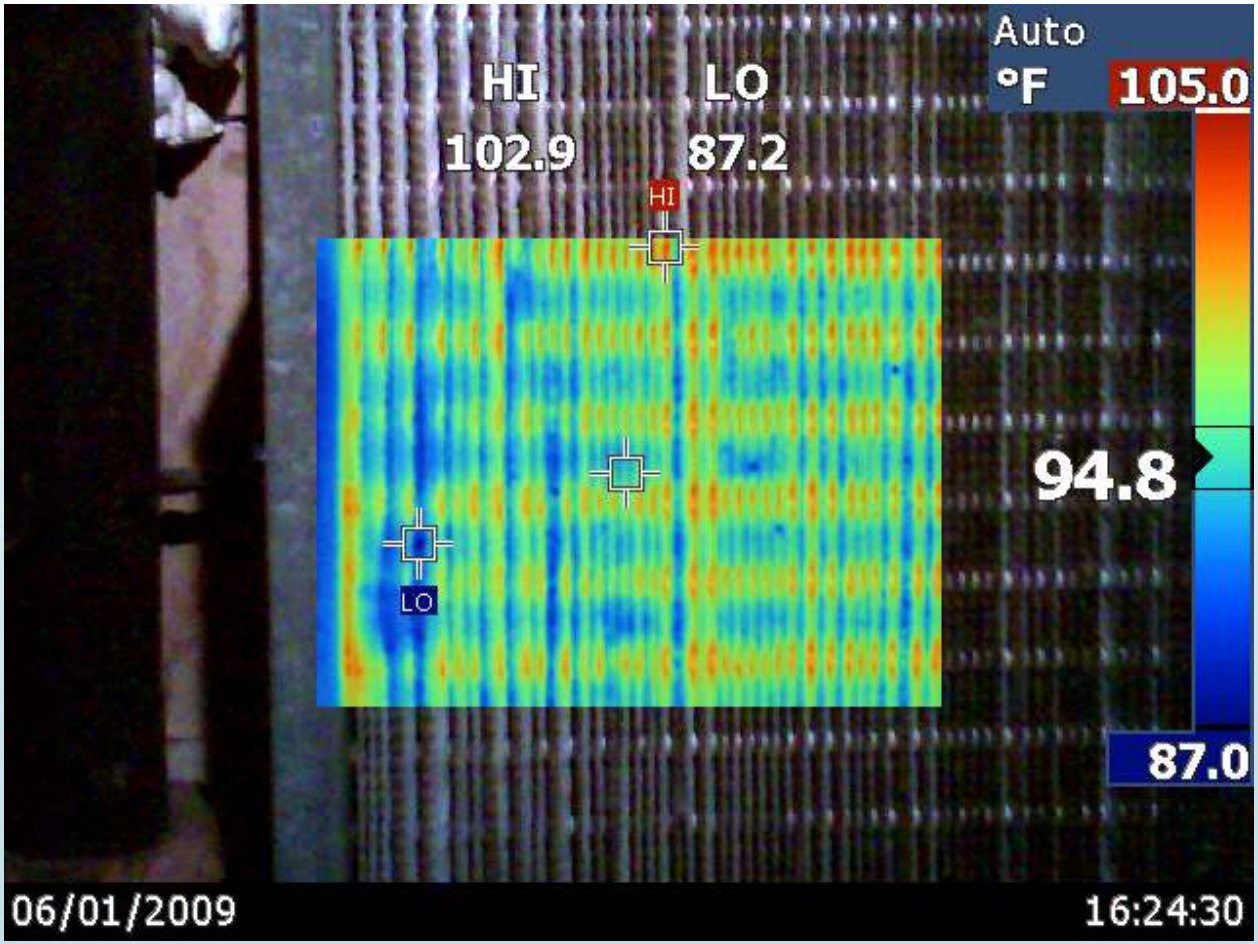
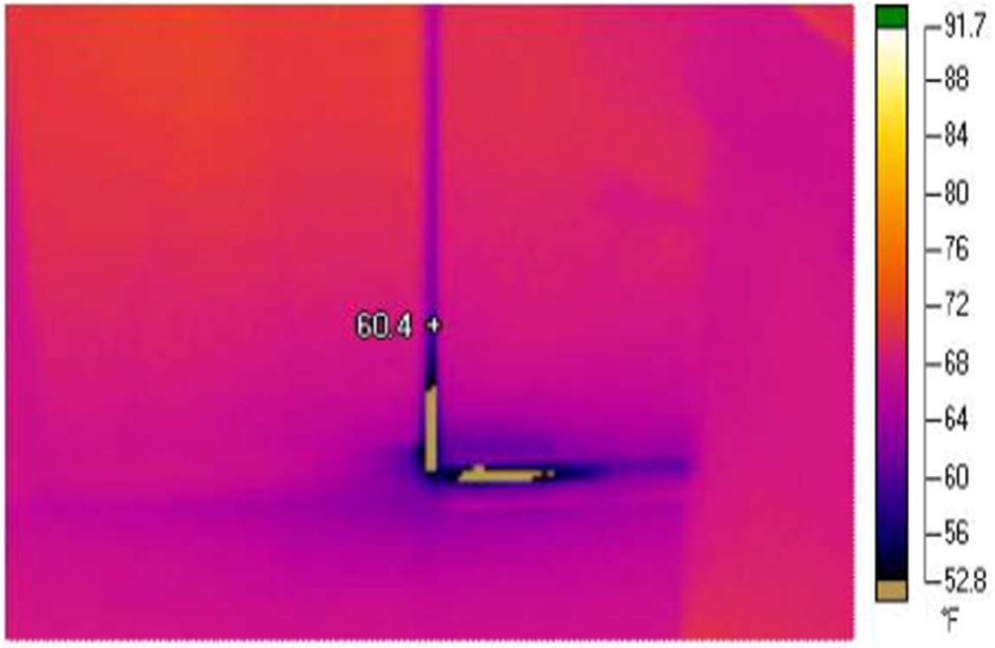


Maintenance and Energy Efficiency

Maintenance and Energy Efficiency



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Visible Light Reference

Economic Analysis for Reach-in Refrigerators

Technology Option	Energy Savings kWh/Year	Energy Savings Percent	Simple Payback $.1627/kWh
ECM Evap Fan Motor (9W, 2 fan)	454	18%	0.6
ECM Cond Fan Motor (20W)	359	14%	0.5
High Efficiency Compressor	171	7%	0.8
ECM Compressor	288	12%	4.8
Variable Speed Compressor	331	13%	3.7
High Efficiency Fan Blade	171	7%	0.2

*U.S DoE, commercial refrigeration equipment research opportunities

Anti-Sweat Heater Controls

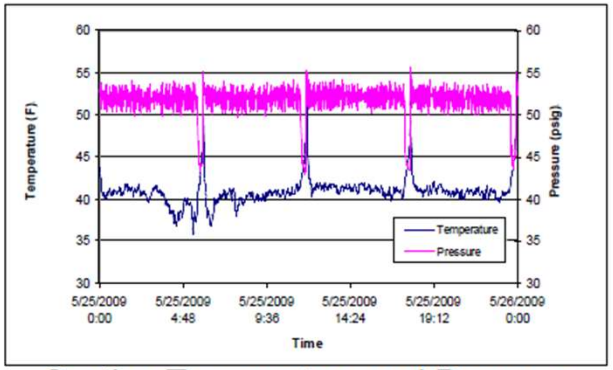
Refrigeration Measures & Specifications	Incentive	Quantity	Extended Incentive
Anti-Sweat Heater Controls to Low temp case (below 0F,)	$21 per linear foot of door width	145’	$3,045
T8 to LED Lights, Side bar (single), Reach-In Cooler / Freezer	$5 per linear foot of lamping	440’	$2,200
Motion Sensors on LED cases, Side bar (single), Reach-In Cooler / Freezer	$1 per linear foot of lamping	440’	$440
Totals Saving over $10,000 on the electric bill. Based on .09 cents.	Total kWh Savings 121,410		$5,685

Add Doors to Open Dairy Case

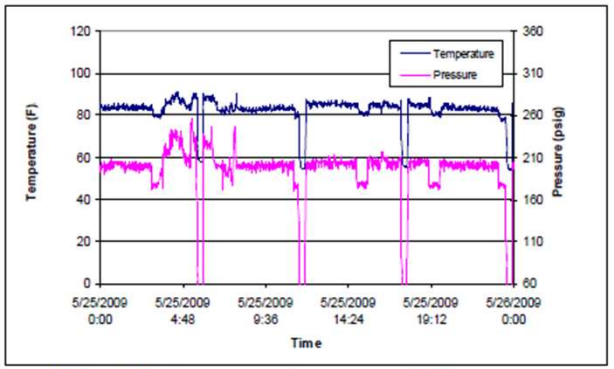
*University of Missouri, Kansas City

Energy Related Data

– New Open Case Line-Up –

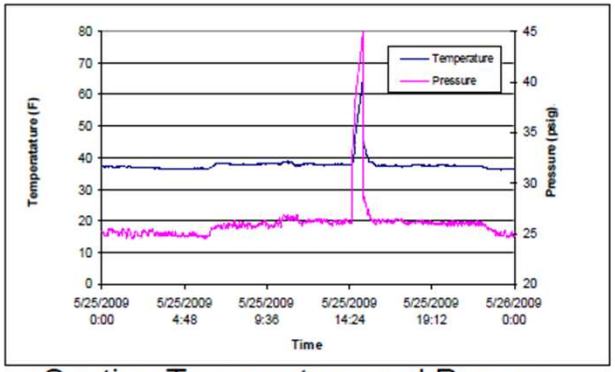


Suction Temperature and Pressure

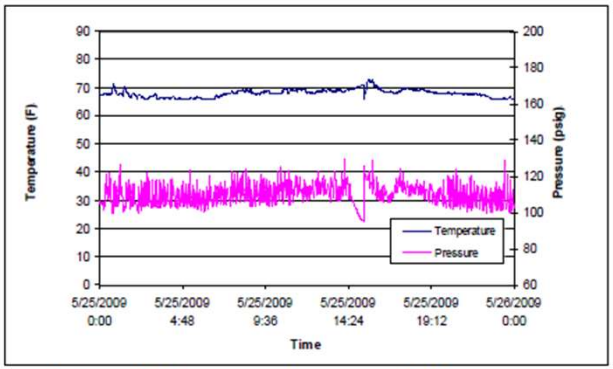


Liquid Temperature and Pressure

– New Doored Case Line-Up –



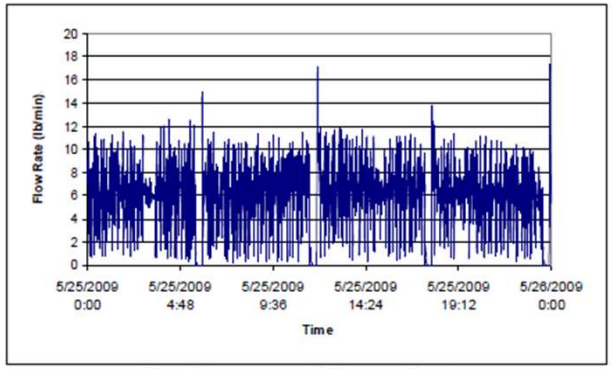
Suction Temperature and Pressure



Liquid Temperature and Pressure

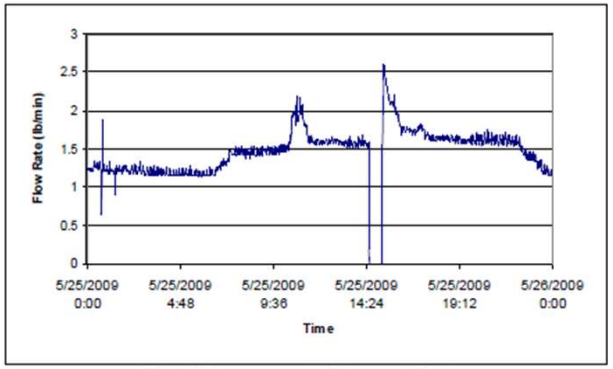
Energy Related Data

– New Open Case Line-Up –

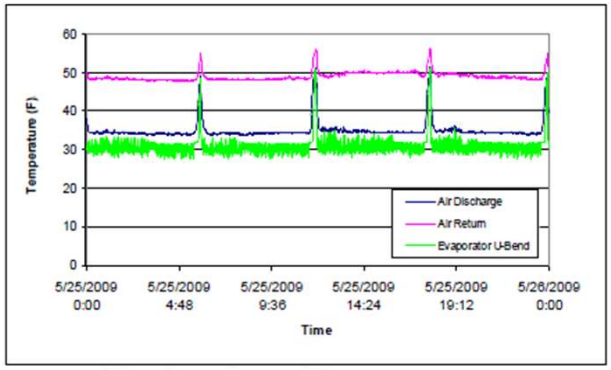


Refrigerant Flow Rate

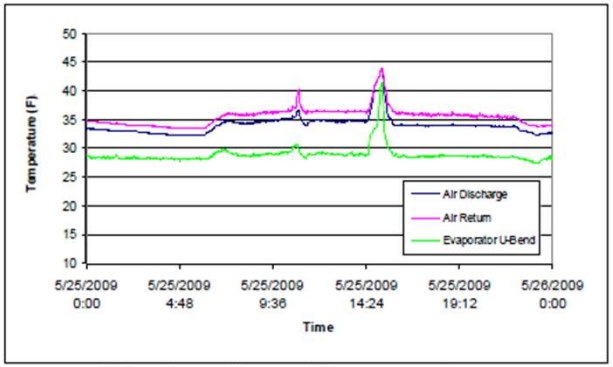
– New Doored Case Line-Up –



Refrigerant Flow Rate



Display Case Temperatures



Display Case Temperatures

Energy Related Data

Mean Electrical Energy Consumption of the Open and Doored Display Case Line-Ups Calculated using ARI/ANSI Standard 1200-2006.

Electrical Energy Consumption	Open Display Case Line-Up	Doored Display Case Line-Up
Compressors (kWh/day)	42.20	11.70
Lights (kWh/day)	5.18	11.93
Fans (kWh/day)	5.69	4.58
Anti-Sweat Heaters (kWh/day)	--	15.50
Total (kWh/day)	53.07	43.72
Total (kWh/day per ft)	2.21	1.71

Energy Saving Ideas in Refrigeration

2019 Columbus ASHRAE

Presenter
Michael Frantz C.E.M.
Lockheed Martin
Field Engineer

Now That You Have a Hand on Energy Saving Ideas

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