NEW TECHNOLOGIES THAT ARE INCREASING SYSTEM EFFICIENCIES

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Topics

- Drivers for geothermal heat pump system efficiency
- Pumping contribution to system efficiency
- Current industry standard pumping solutions
- New variable speed pumping technologies
- System efficiency case study; comparison of traditional and new technologies

Drivers for geothermal heat pump system efficiency

- Main drivers of system efficiency
  - Geothermal Heat Pump unit efficiency
  - Duct design and installation
  - Ground loop design and installation
  - Pumping efficiency

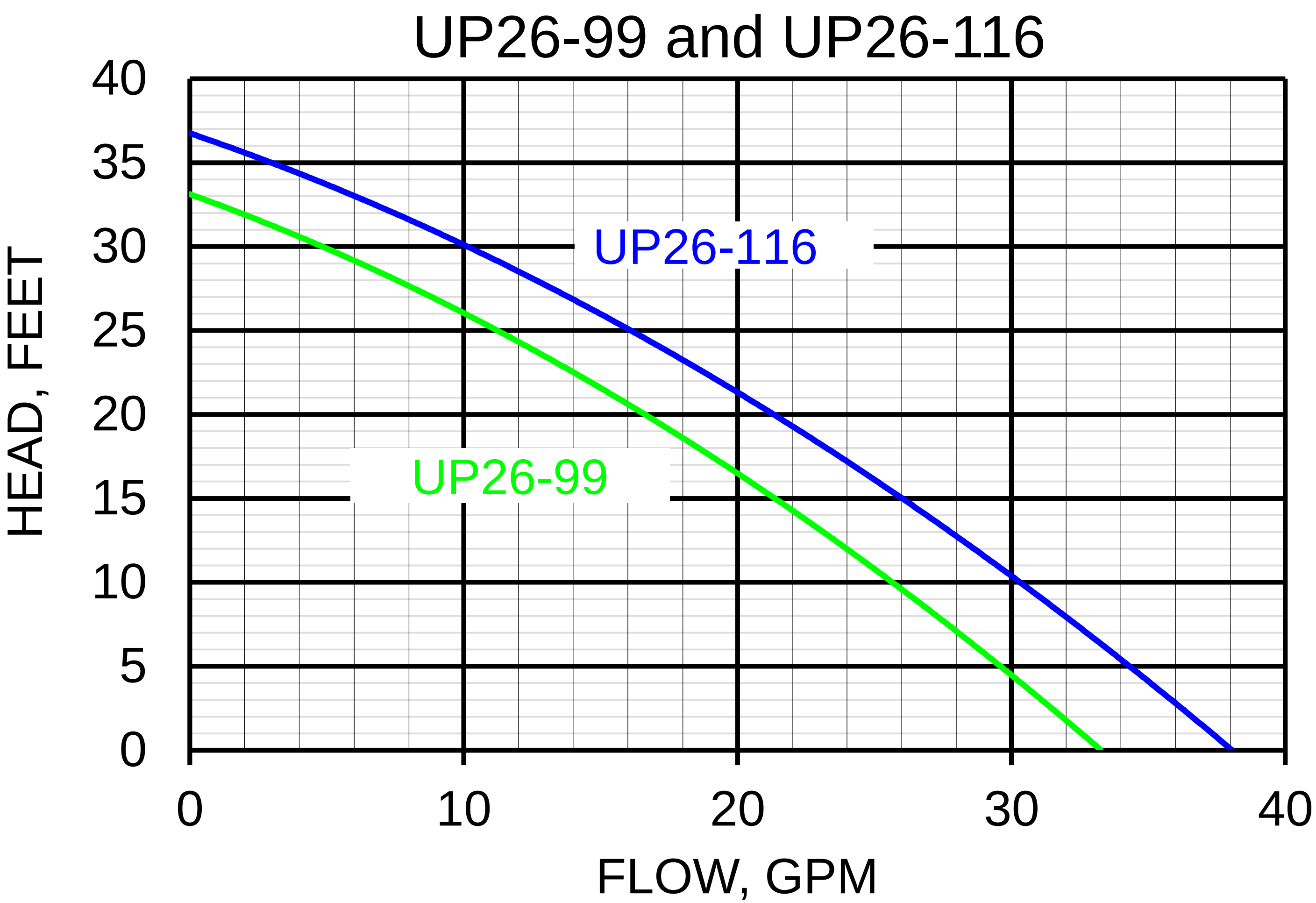
Pumping contribution to system efficiency

- Manufacturers catalog data for COP/EER does not include pumping watts
- AHRI/ISO/ASHRAE 13256-1 certified data for COP/EER includes pump watts based on the following formula:
  - Pump power correction (W) = (gpm x 0.0631) x (Press Drop x 2990) / 300
  - Where "Press Drop" is the pressure drop through the ***unit's heat exchanger*** at rated water flow in feet of head
  - Example: 4 ton system with 10.5 ft-hd @12 gpm
    - Pump power correction=79.2 Watts
    - This is incredibly low, and causes AHRI efficiency to be overstated in most cases
- Pumping watts can be significant, and will affect system COP/EER

Current industry standard pumping solutions

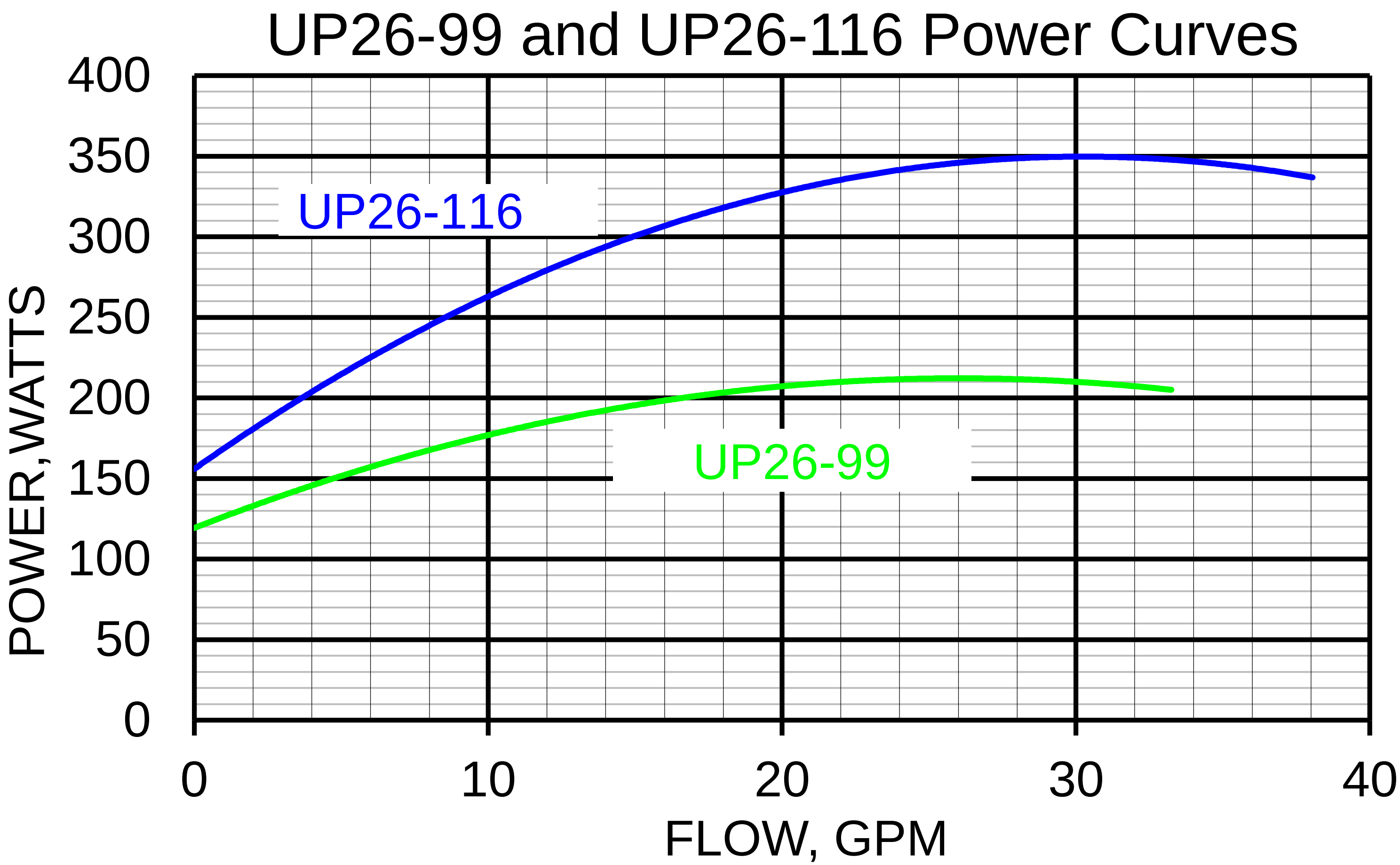
- Single speed pumps and multi-speed pumps
  - Wet rotor circulators most commonly used for closed loop systems
  - Pump manufacturers include Grundfos, Wilo, Taco, B&G, and others
  - Grundfos UP26-99 and UP26-116 have greatest share of market
- ECM circulator
  - Wilo Stratos with integrated differential pressure control
  - Not widely used in residential single unit installations

Current industry standard pumping solutions



Current industry standard pumping solutions

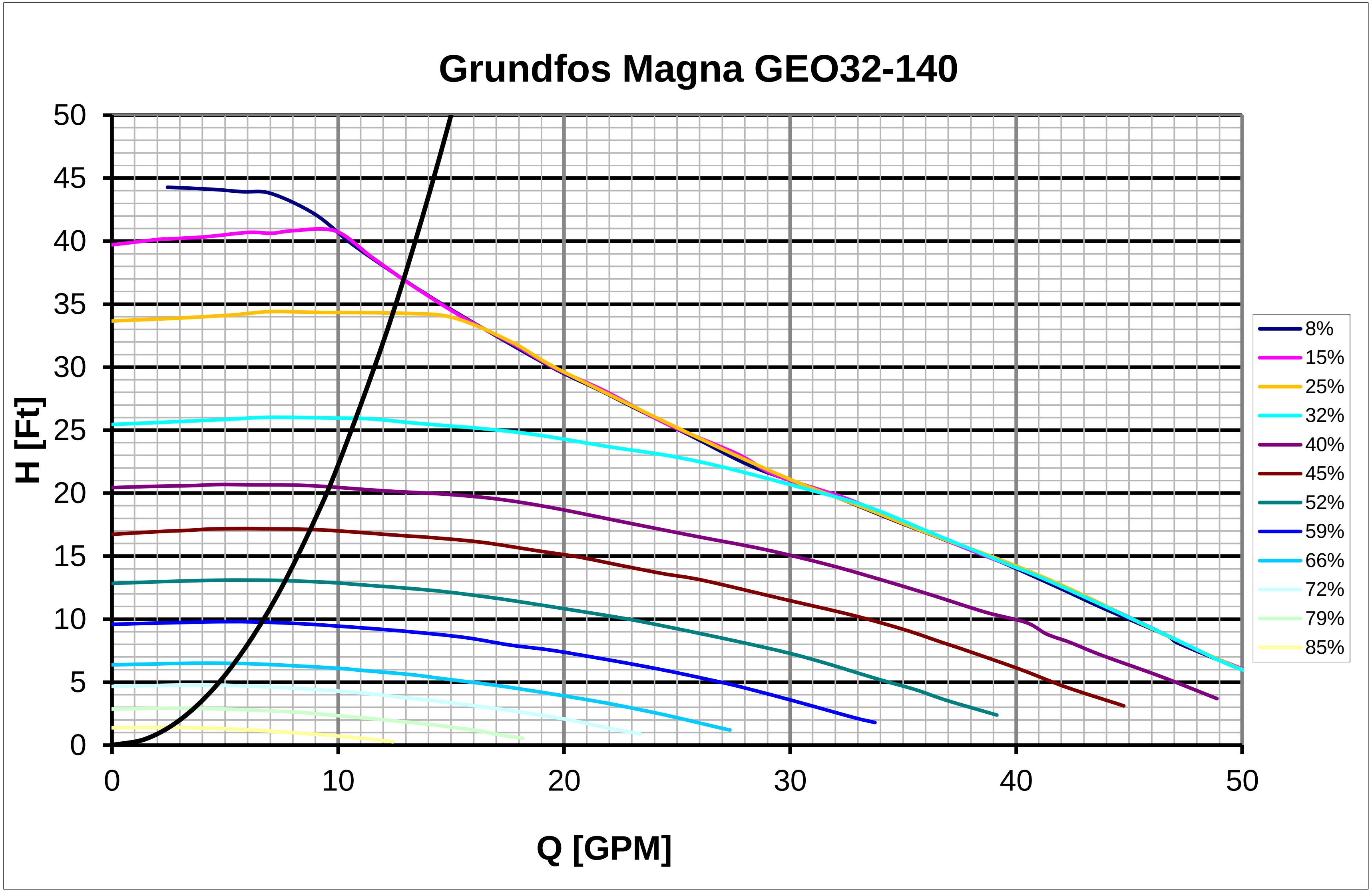
- UP26-99 nameplate power=245 W
- UP26-116 nameplate power=377 W



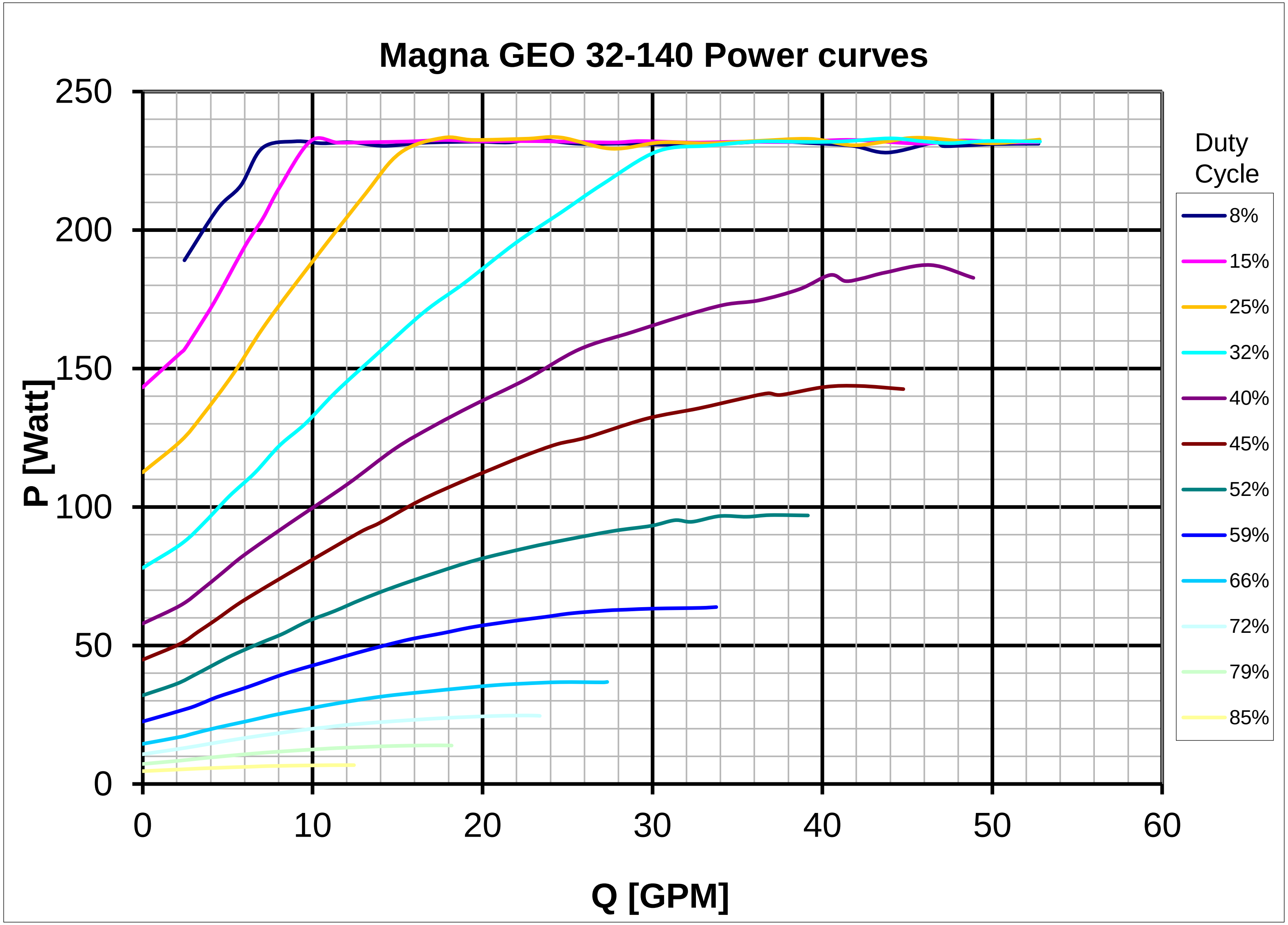
New variable speed pumping technologies

- ECM pumps with dedicated controllers
  - Allow pumps to be controlled by specified flow rate, or specified ΔT (differential temperature)
  - Allows actual specified flow rate to be used
  - Higher performance of pumps may allow for single pump instead of two per system
  - Some controllers allow specified flow rates for multi-stage heat pumps and multi-unit installations

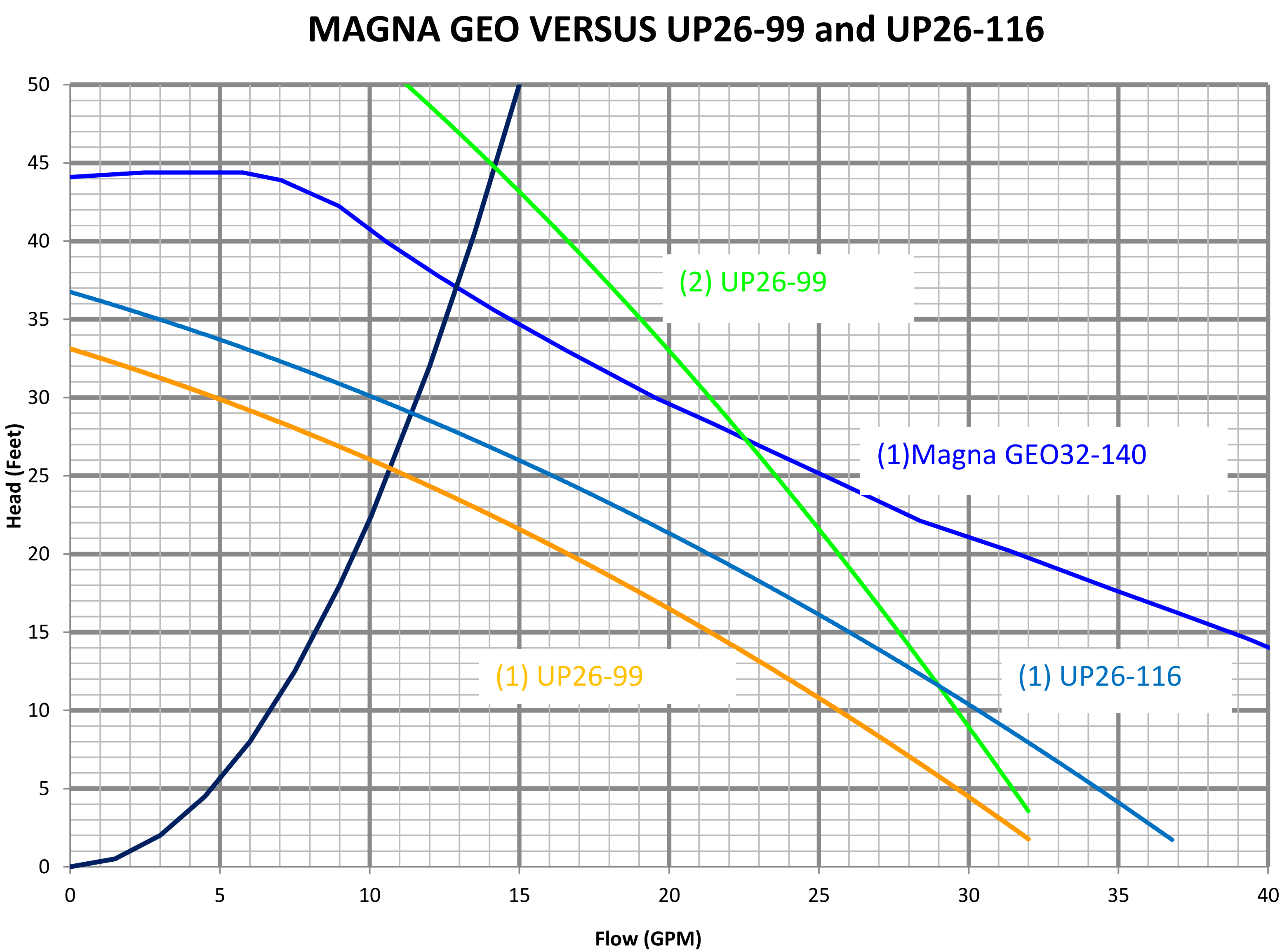
New variable speed pumping technologies



New variable speed pumping technologies



New variable speed pumping technologies



Case Study Parameters

- 4 ton heat pump, two-stage
- 10.5 ft-hd @ 12 gpm with 30° EWT
- Loop Circuits: (4) 800’ ¾” SDR11 HDPE pipe (PE 3408/3608)
- Header piping: 20’ of 1-1/4” SDR11 pipe
- Supply/Return (Inside): 10’ of 1-1/4” SDR11 pipe
- Heat pump piping: 1” hose kit with 5’ of rubber hose
- 25% propylene glycol (13.8° F freeze protection)

Manufacturer’s performance data: Full Load

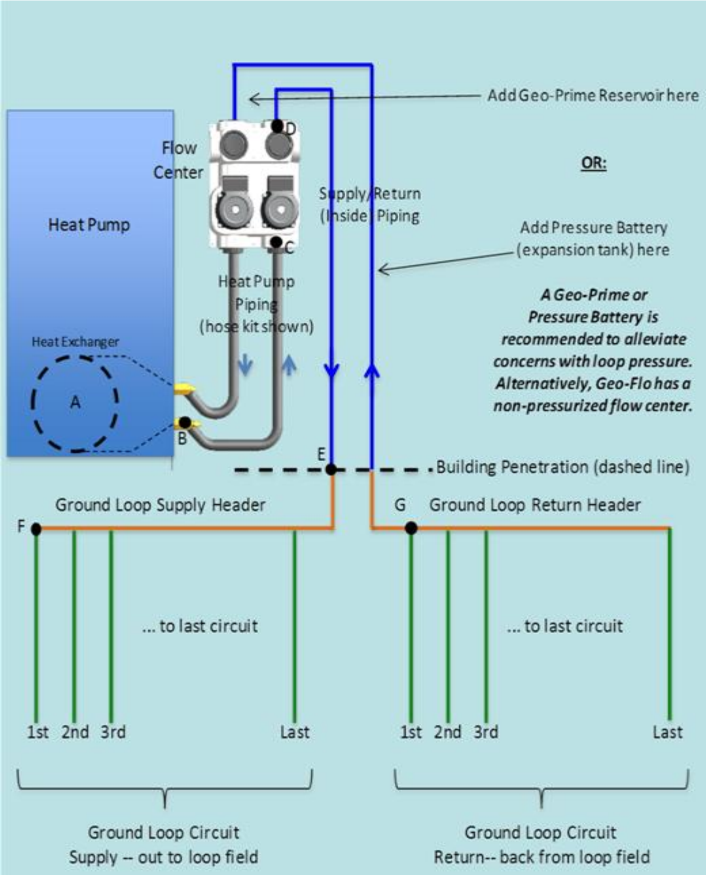
EWT °F	GPM	WPD		Heating - EAT 70°F						
		PSI	FT	Airflow CFM	HC	kW	HE	LAT	COP	HW
20	12.0	4.8	11.0	1430	31.6	2.90	22.1	90.5	3.20	2.7
	12.0	4.8	11.0	1650	32.3	2.78	22.9	88.1	3.40	2.7
30	6.0	1.3	2.9	1430	34.7	2.98	24.9	92.5	3.41	3.2
	6.0	1.3	2.9	1650	35.4	2.86	25.7	89.9	3.62	3.3
	9.0	2.7	6.1	1430	36.3	3.03	26.3	93.5	3.51	3.4
	9.0	2.7	6.1	1650	37.0	2.90	27.2	90.8	3.73	3.4
	12.0	4.6	10.5	1430	37.2	3.05	27.0	94.1	3.57	3.5
	12.0	4.6	10.5	1650	37.9	2.93	28.0	91.3	3.79	3.5

Manufacture’s performance data: Part Load

EWT °F	GPM	WPD		Heating - EAT 70°F						
		PSI	FT	Airflow CFM	HC	kW	HE	LAT	COP	HW
20	11.0	4.0	9.3	1200	23.2	2.16	16.2	87.9	3.14	2.3
	11.0	4.0	9.3	1400	23.5	2.10	16.6	85.5	3.27	2.3
30	5.5	1.1	2.5	1200	25.6	2.20	18.6	89.8	3.42	2.5
	5.5	1.1	2.5	1400	25.9	2.14	18.9	87.2	3.56	2.5
	8.3	2.3	5.2	1200	26.6	2.21	19.4	90.5	3.52	2.6
	8.3	2.3	5.2	1400	26.9	2.15	19.8	87.8	3.67	2.6
	11.0	3.9	8.9	1200	27.1	2.22	19.9	90.9	3.58	2.7
	11.0	3.9	8.9	1400	27.4	2.15	20.3	88.1	3.73	2.7

Case Study Parameters

Antifreeze	Antifreeze / Percentage by Volume (% not applic. for water)	Propylene Glyco	25.C %
Heat Pump	Heat pump nominal flow rate (full load) -- U.S. GPM	12.0	GPM
	Heat exchanger pressure drop (point A on drawing) @ 30 deg F	10.5	ft. of hd.
Heat Pump Piping	Choose piping between heat pump and flow center (B to C)	1" Hose Kit	
	Diameter (in.) of heat pump piping (B to C) -- Ignore if using hose kit	1.00	in.
	Length (ft.) of heat pump piping (B to C -- one side only)	5.0	ft.
	# of elbows in heat pump piping (one side only) -- Ignore if hose kit	0	
Supply / Return	Material of supply/return piping	PE3408/3608 SC	
	Diameter (in.) of supply/return piping (D to E)	1.25	in.
	Length (ft.) of supply/return piping (D to E -- one side only)	10.0	ft.
	# of elbows in supply/return piping (one side only)	2	
Header	Material of header piping	PE3408/3608 SC	
	Diameter (in.) of header piping (E to F)	1.25	in.
	Length (ft.) of header piping (E to F -- one side only)	20.0	ft.
	# of elbows in header piping (one side only)	1	
Loop Circuit	Material of ground loop circuit	PE3408/3608 SC	
	Diameter (in.) of ground loop circuit piping	0.75	in.
	# of ground loop circuits (connected at F) NOTE: Ts are calculated based on circuits.	4	
	# of elbows in each ground loop circuit (u-bend should be entered as 2 elbows). NOTE: Only enter the elbows for one circuit, not for all.	0	
	Total length in ft. (F to G) of ground loop circuit	800	ft.

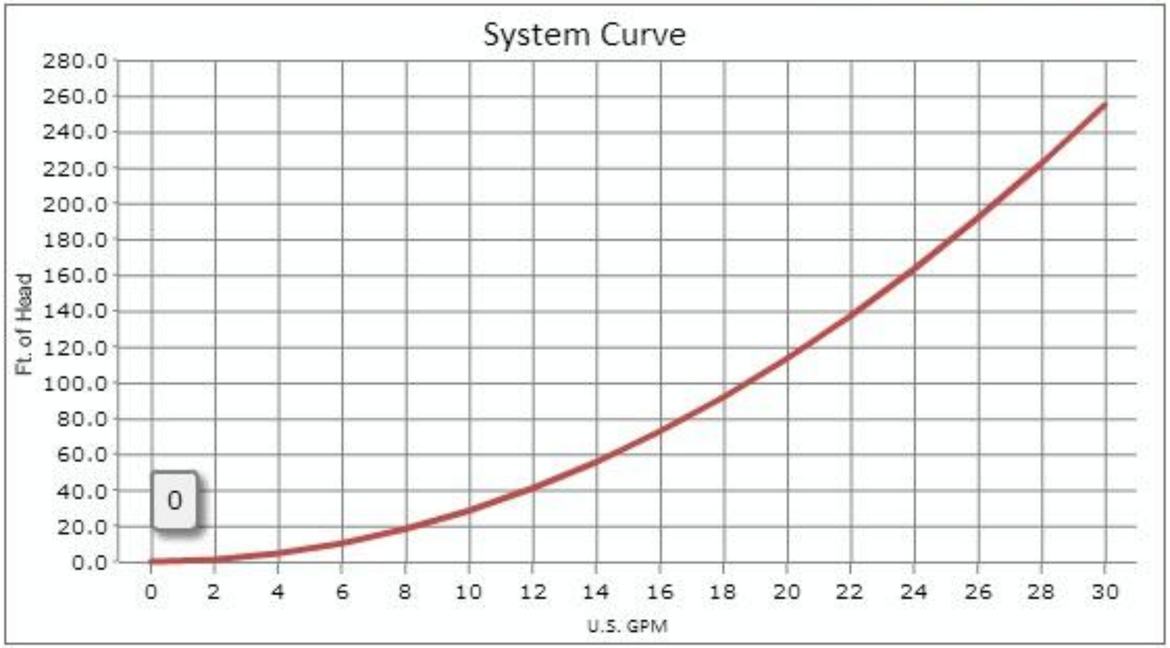


Pressure Drop Results

System Pressure Drop Calculations:

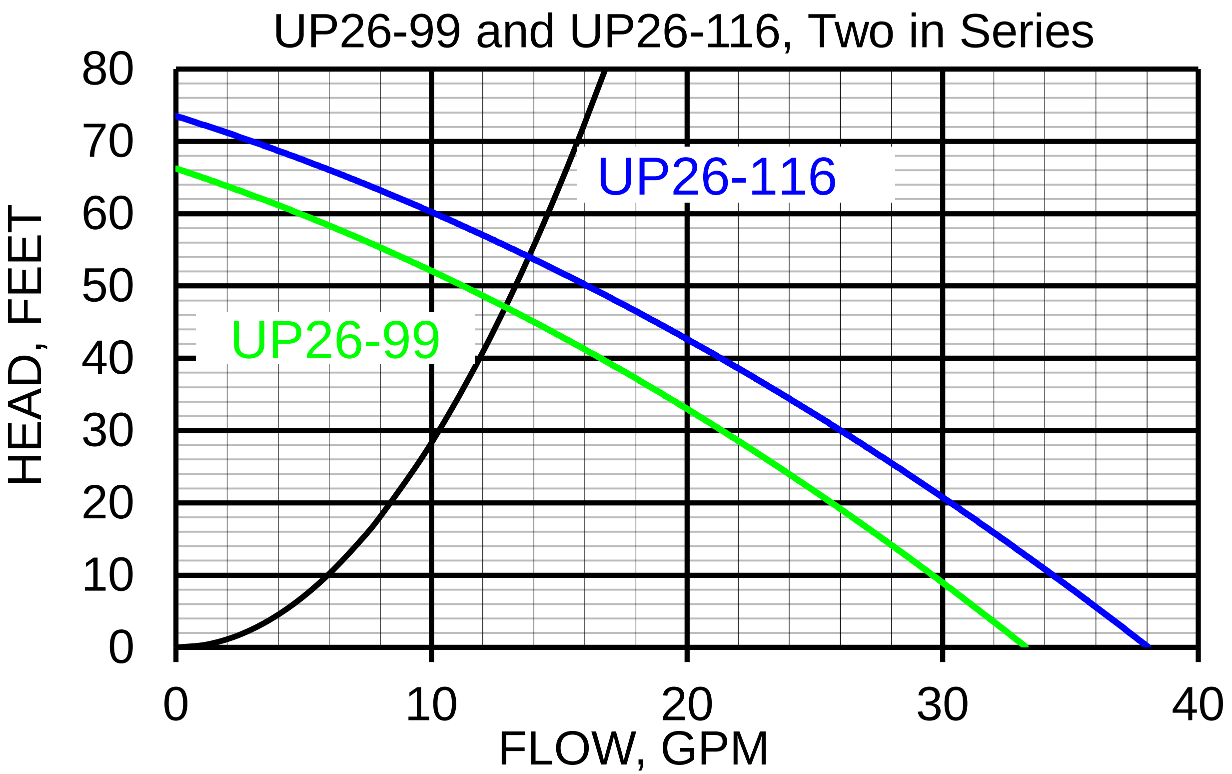
Heat Pump	12 ft. of head @ 12 U.S. GPM (corrected for antifreeze)
Heat Pump Piping	0.7 ft. of head @ 12 U.S. GPM
Inside Supply/Return Piping	1.1 ft. of head @ 12 U.S. GPM
Header Piping	3.3 ft. of head @ 12 U.S. GPM
Loop Circuit Piping	23.7 ft. of head @ 3 U.S. GPM
Additional Pressure Drop	0 ft. of head @ 12 U.S. GPM
System Pressure Drop	**40.8 ft. of head @ 12 U.S. GPM**
Total System Volume	105 U.S. Gallons
Antifreeze Needed @ 25%	26.3 U.S. Gallons
Flushing Requirements	14.4 U.S. GPM @ 58.8 ft. of head (with parallel reducing header)

40.8 ft-hd@12 GPM



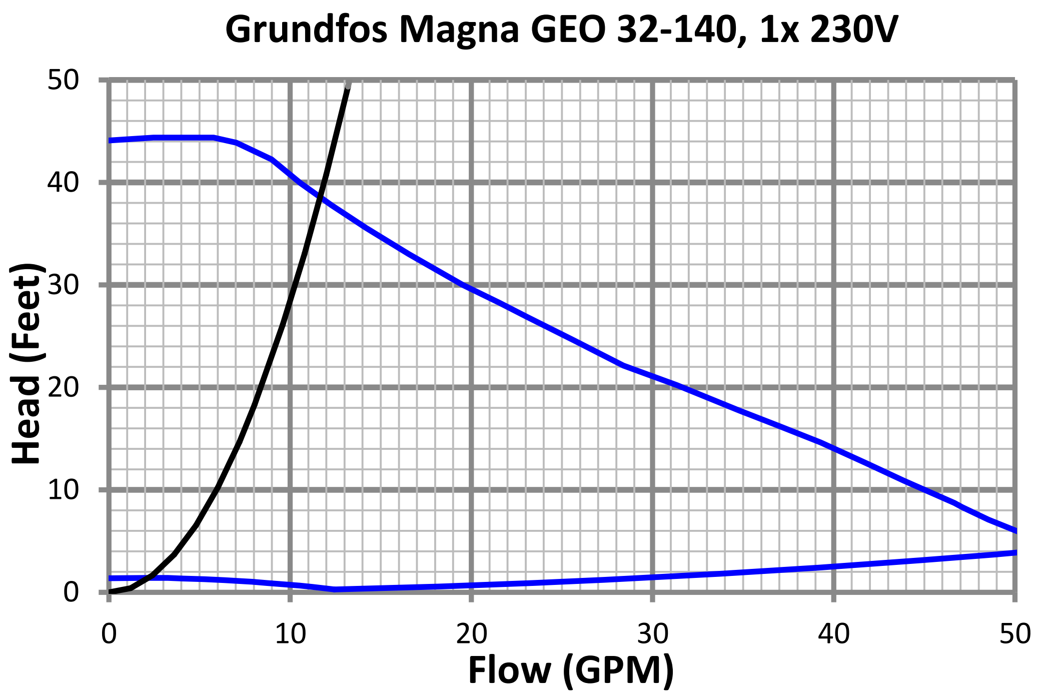
Traditional Pumping Solution

- Rule of thumb pump sizing: Two pumps in series



- UP26-116: 13.7 GPM @53.2 Ft-Hd, 572 Watts
- UP26-99: 12.8 GPM @46.4 Ft-Hd, 376 Watts

New Pumping Technology Solution



- Magna GEO 32-140: 11 GPM@34.9 ft-hd, 197 W(1st stage)
- Magna GEO 32-140: 12 GPM@37.5 ft-hd, 230 W (2nd stage)
- Magna GEO 32-140: 8.3 GPM@21.1 ft-hd, 79 W (1st stage)
- Magna GEO 32-140: 9 GPM@ 24.4 ft-hd, 96 W (2st stage)

Power Comparison of Technologies

Pump(s)	Ave. Watts	Cost per kWh	Run hours per year	Cost per year
(2)UP26-116	572	$ 0.10	4145	$ 237.09
(2)UP26-99	376	$ 0.10	4145	$ 155.85
GEO 32-140*	203.6	$ 0.10	4145	$ 84.39
GEO 32-140**	82.4	$ 0.10	4145	$ 34.15

- Assumed 4,145 hours per year for two-stage unit with 80% on 1st stage and 20% on 2nd stage
- *Based on manufacturer's recommended nominal flow rates of 11 & 12 gpm for 1st and 2nd stage operation
- **Based on manufacture's minimum recommended flow rates of 8.3 & 9 gpm for 1st and 2nd stage operation

Efficiency Comparison of Technologies

- Manufacture's performance data: Full Load

EWT °F	GPM	WPD		Heating - EAT 70°F						
		PSI	FT	Airflow CFM	HC	kW	HE	LAT	COP	HW
20	12.0	4.8	11.0	1430	31.6	2.90	22.1	90.5	3.20	2.7
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	12.0	4.6	10.5	1650	37.9	2.93	28.0	91.3	3.79	3.5

- COP= [Heating Capacity/Power Input]÷3.412
- Actual COP with UP26-116s:
  - COP=[37.9/(2.93+.572)] ÷3.412=3.17
- Actual COP with UP26-99s:
  - COP=[37.9/(2.93+.376)] ÷3.412=3.35
- Actual COP with Magna GEO: (12 GPM setting)
  - COP=[37.9/(2.93+.230)] ÷3.412=3.52
- Actual COP with Magna GEO: (9 GPM setting)
  - COP=[37/(2.90+.098)] ÷3.412=3.62

Efficiency Comparison of Technologies

- Manufacture’s performance data: Part Load

EWT °F	GPM	WPD		Heating - EAT 70°F						
		PSI	FT	Airflow CFM	HC	kW	HE	LAT	COP	HW
20	11.0	4.0	9.3	1200	23.2	2.16	16.2	87.9	3.14	2.3
	11.0	4.0	9.3	1400	23.5	2.10	16.6	85.5	3.27	2.3
30	5.5	1.1	2.5	1200	25.6	2.20	18.6	89.8	3.42	2.5
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	11.0	3.9	8.9	1400	27.4	2.15	20.3	88.1	3.73	2.7

- Actual COP with UP26-116s:
  - COP=[27.4/(2.15+.572)] ÷3.412=2.95
- Actual COP with UP26-99s:
  - COP=[27.4/(2.15+.376)] ÷3.412=3.18
- Actual COP with Magna GEO: (at 11 gpm)
  - COP=[27.4/(2.15+.197)] ÷3.412=3.42
- Actual COP with Magna GEO: (at 8.3 gpm)
  - COP=[26.9/(2.15+.079)] ÷3.412=3.54

Efficiency Comparison of Technologies-Summary

Pump(s)	COP-Full Load	COP-Part Load	% Increase vs. UP26-116		% Increase vs. UP26-99	
			Full Load	Part Load	Full Load	Part Load
(2) UP26-116	3.17	2.95	NA	NA	NA	NA
(2) UP26-99	3.35	3.18	6%	8%	NA	NA
Magna GEO at nominal flow	3.52	3.42	11%	16%	5%	8%
Magna GEO at minimum flow	3.62	3.54	14%	20%	8%	11%

- AHRI Full Load COP rating: 4.0 (at 32 F, ground loop system, 15% methanol)
- AHRI Part Load COP rating: 4.5 (at 41 F, ground loop system, 15% methanol)
- Manufacturer's Full Load COP rating: 3.79 (at 30 F, 12 GPM)
- Manufacturer's Part Load COP rating: 3.73 (at 30 F, 11 GPM)

Application of New Technology

- Can these results be achieved in the field?

- Actual Field Data: 4-ton heat pump (Model 049)
  - 1st Stage: EWT=46.8 F, LWT= 39.8 F, 8.0 GPM, 55 Watts
  - 2nd Stage: EWT=43.6 F, LWT= 37.5 F, 12.0 GPM, 177 Watts

Summary

- New pumping and control technologies can both decrease operating costs and increase overall system efficiency
- Products (heat pumps, circulators, controllers, etc.) alone will not optimize system efficiency
- Contractors/designers should utilize software resources (many are free) to apply technology most affectively

QUESTIONS?