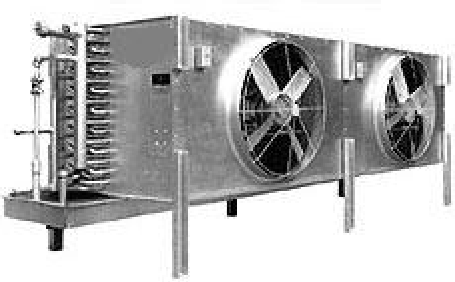
Midwest Mechanical
Services & Solutions

2324 Centerline Industrial Drive - St. Louis, MO 63146 - 314-707-7655 - www.midweststl.com

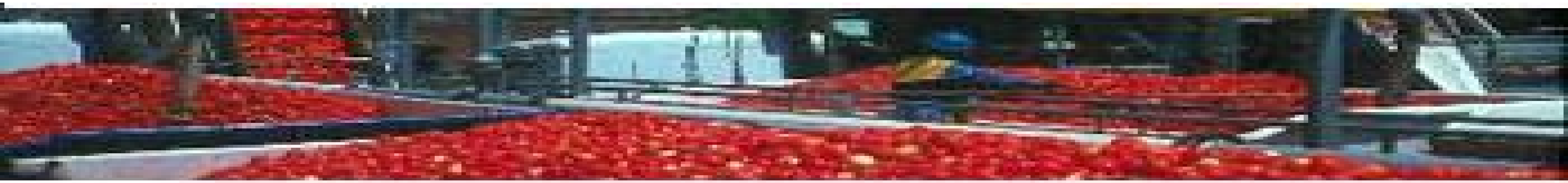
Refrigeration

Understanding Relationships



Refrigeration Efficiency =

Precise Load Matching +
Lower Compression Ratios



Basic Approach Strategies:

- Capacity Requirements based on intended use in lieu of "Rule of Thumb" sizing.
- Compressor Selection Based on Year-Round Load Characteristics.
- Condenser Capacity Optimization
- Low Pressure Drop Piping Design
- Third Power Fan and Pump Laws
- Floating but Stable Discharge Pressures
- Floating Suction Pressures
- Premium High Efficiency Motors
- Integrated and Flexible PLC Control Systems.

MIDWEST MECHANICAL WANTS TO EARN YOUR REFRIGERATION BUSINESS:

- SERVICE
- PARTS
- UPGRADES
- NEW PROJECTS

AMMONIA & FREON REFRIGERATION SYSTEMS

How We Can Save You Money:

- Improved Production
- Increased "Up Time"
- Reduction in Energy Costs
- Demand Cost Avoidance
- Lower Maintenance Costs
- FREE Mechanical Risk Index (MRI)
- Records of Performance
- Increased Profits and Customer Satisfaction
- Improved Utilization of Resources

CONTACTS:

MIKE CASSANO - INDUSTRIAL REFRIGERATION MANAGER
E-Mail: MCassano@midweststl.com

MATT RICHARDSON - VICE PRESIDENT OF OPERATIONS
E-Mail: MRichardson@midweststl.com

Refrigeration industry characteristics

- **Large energy users, high load factor**
- **Facilities expanded over time, always evolving**
- **Risk averse, slow to change**
  - high cost of investments and mistakes
  - experience takes time
  - heavy reliance on plant operators, transferred knowledge
- **No national/state ratings or standards for refrigeration equipment**
- **Systems not "packaged"**
  - systems are built of components
  - every application and each system is different
- **Minimal A&E influence**

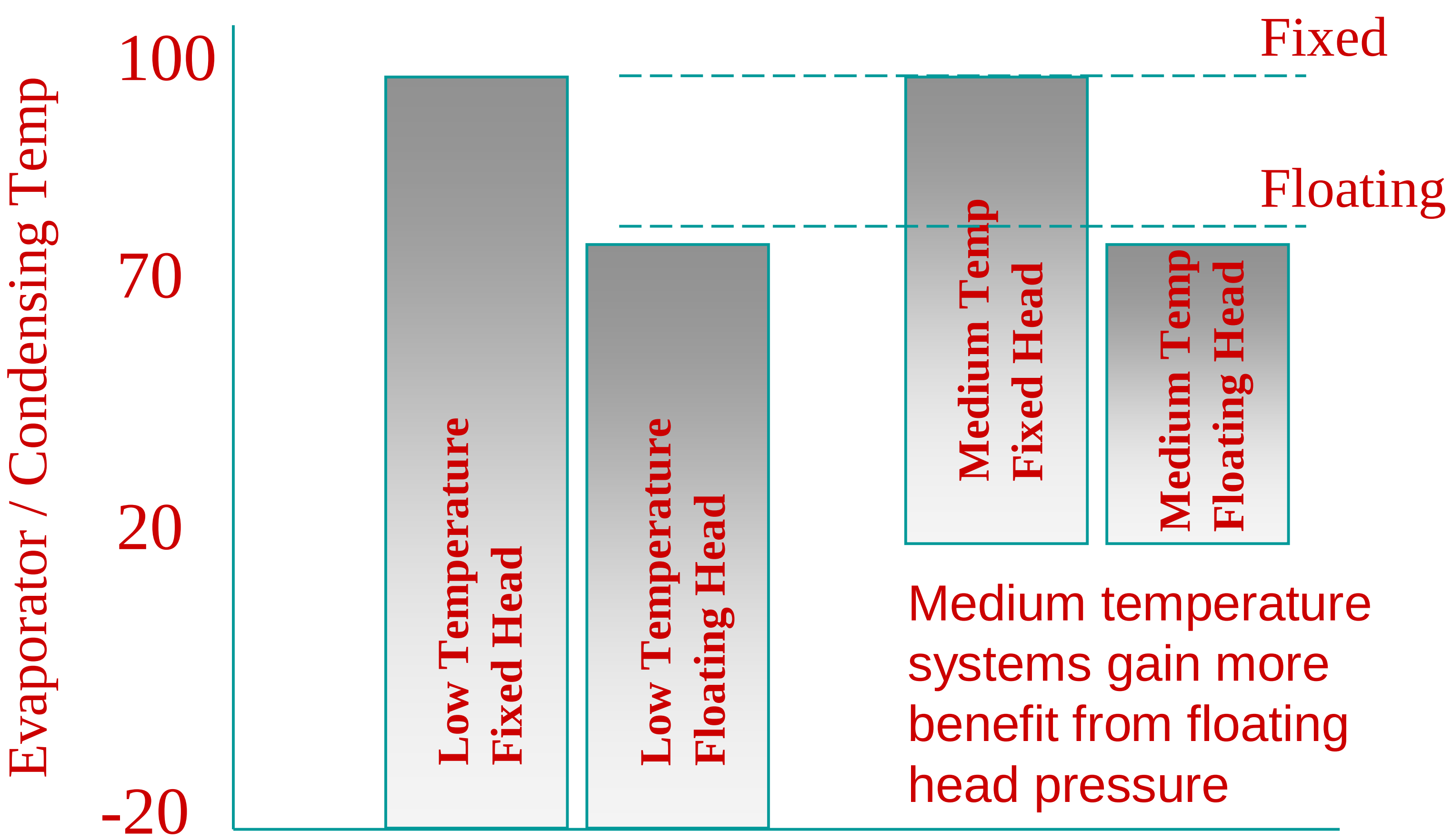
Industrial refrigeration systems
themes that impact energy efficiency

- **Large difference in design vs. average load**
- **Systems operated at fixed settings**
- **Characteristically difficult to control**
  - Relatively unstable due to low circuit mass
- **Slide valve losses are a large inefficiency**
- **Multiple compressor sequencing challenges**
  - Typical over-control (hunting) vs. actual load needs
  - Manual sequence control is common
  - No well developed methodology or control theory
- **25%+ savings potential (actual vs. ideal)**

Industrial refrigeration Cost and Energy Efficiency Opportunities

- Equipment selection
  - Component Selection to Maximize Tons/kW
  - Sizing: base design on actual loads vs transient values
- Minimize “lift”:
  - Floating suction pressure, floating head pressure
- Variable speed – various applications
- System design focused on:
  - Reliable Proven Equipment and Design Practices
  - Control for Off-design conditions
  - Ease of Service and Low Maintenance Costs
  - Prepiped Packaged Solutions

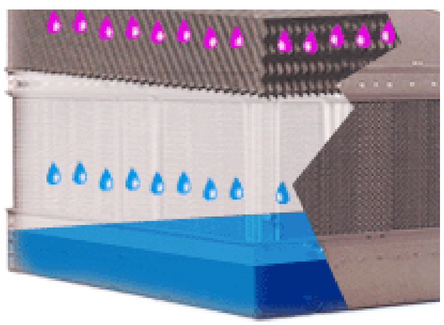
Refrigeration system "lift"



Condensers – design and selection practice

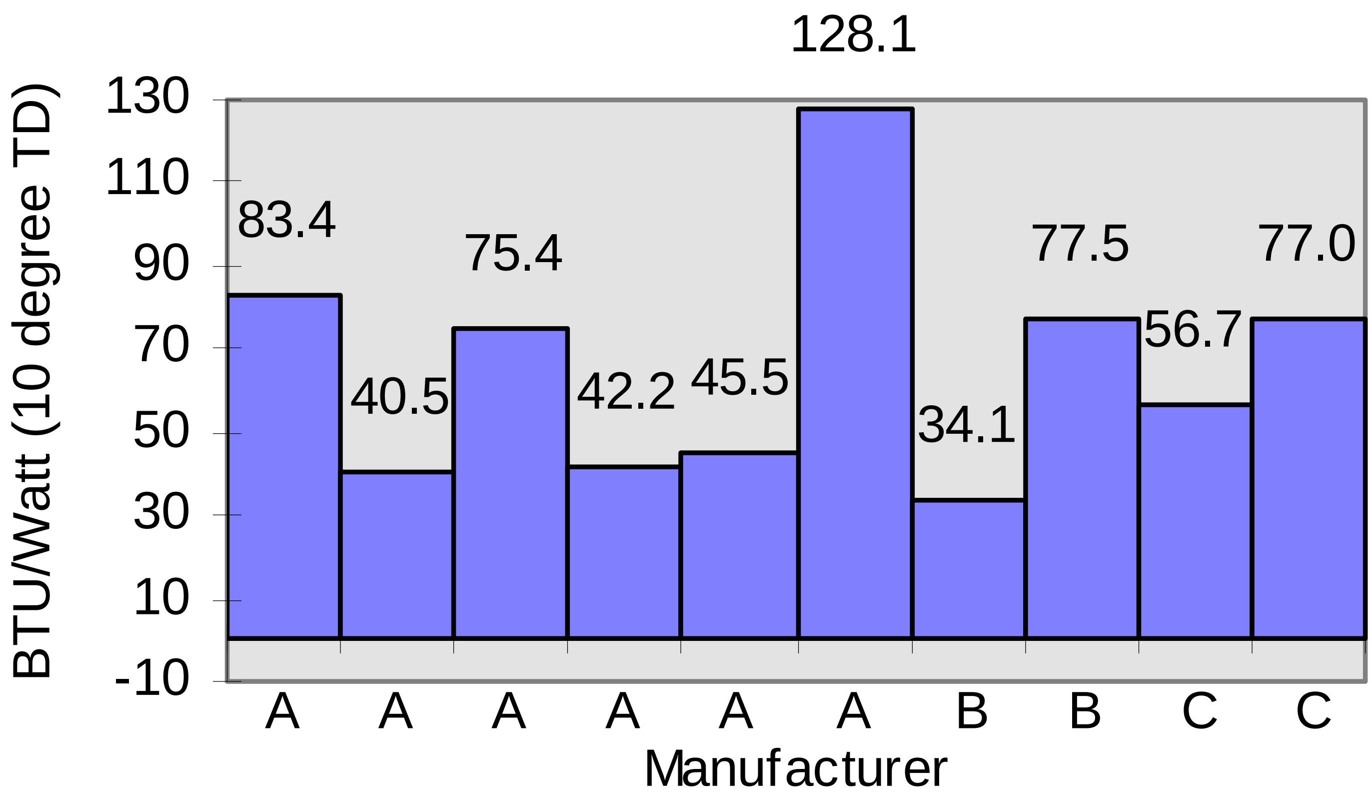
- **Nominal sizes stem from HVAC practice**
- **Air cooled condensers**

  - capacity varies with ambient Dry Bulb Temp
  - past practice driven by limiting maximum pressures
  - sizing TD of 10 F (LT) to 15 F (MT) unchanged for years
  - but, big range in motor size
- **Evap cooled condensers**



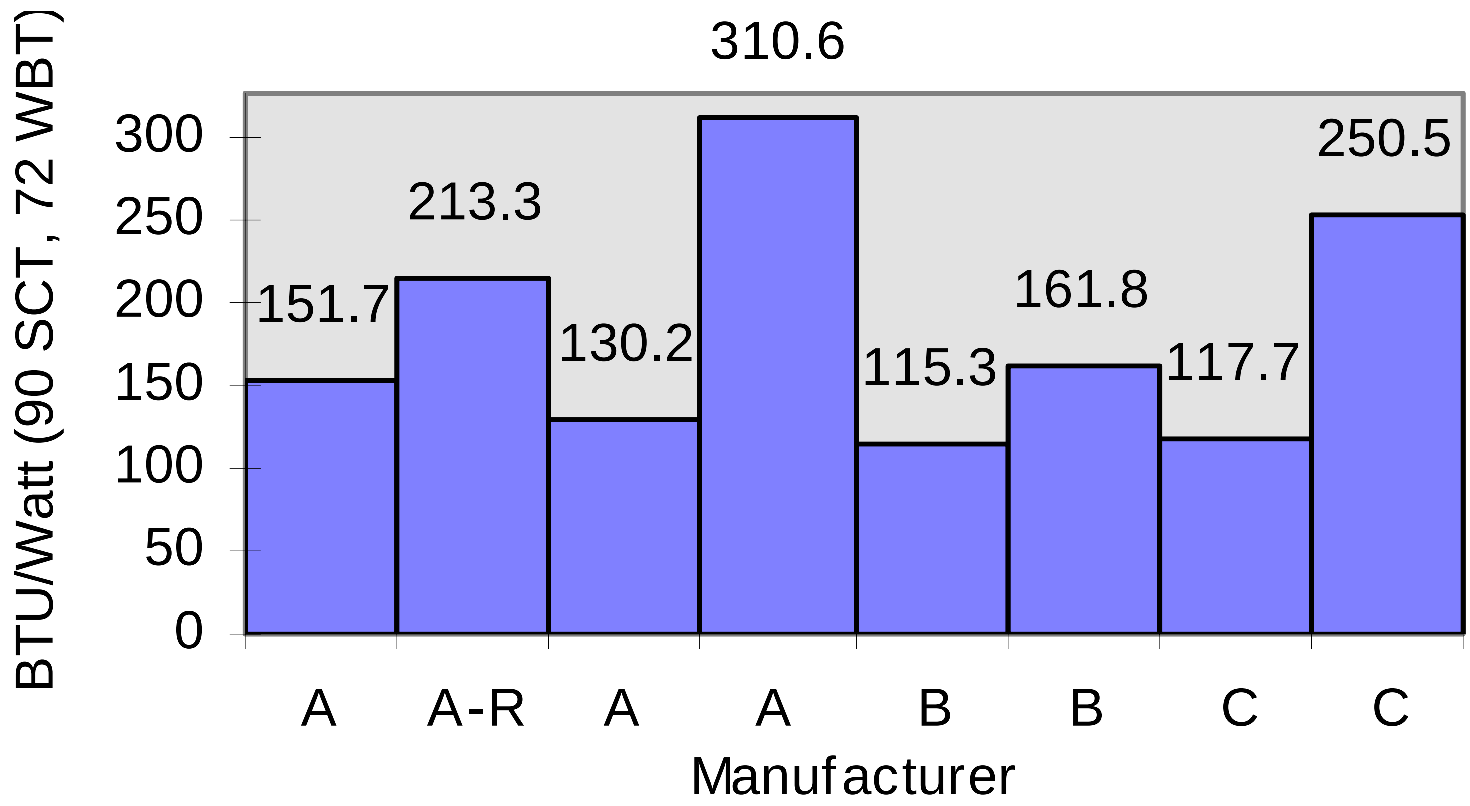
  - capacity varies with Wet Bulb Temp
  - past industry practice based on first cost (95 F SCT)
  - TD declining over time: 25° >> 16° >> 10°(?)
  - big range in fan power
- **Wide range of catalog efficiencies**

Variation in efficiency – air cooled



Examples of air cooled condenser specific efficiency

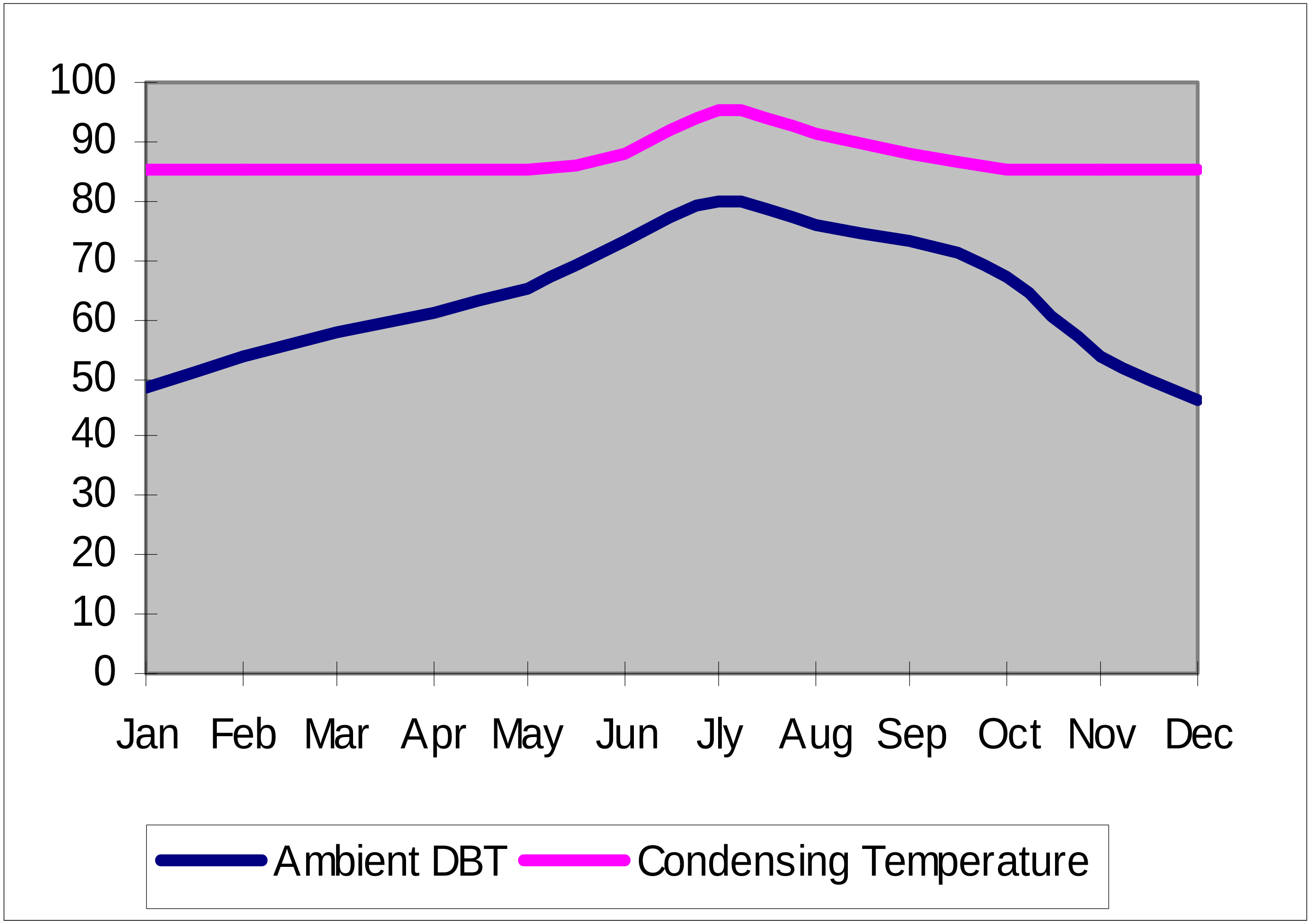
Variation in efficiency – evap cooled



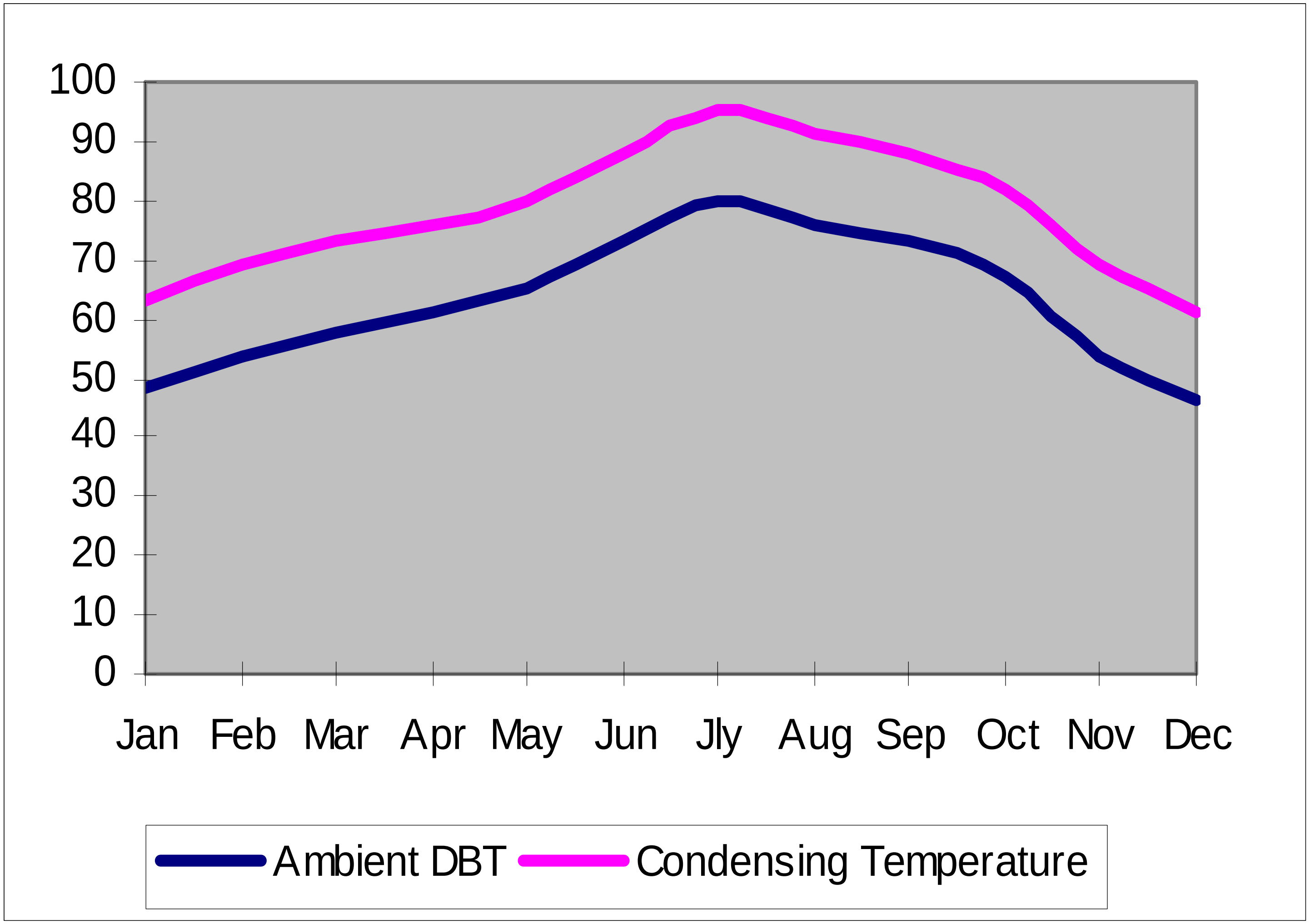
Examples of evap cooled condenser specific efficiency

Heat Rejection Control: Floating Head Pressure and Variable Speed Application

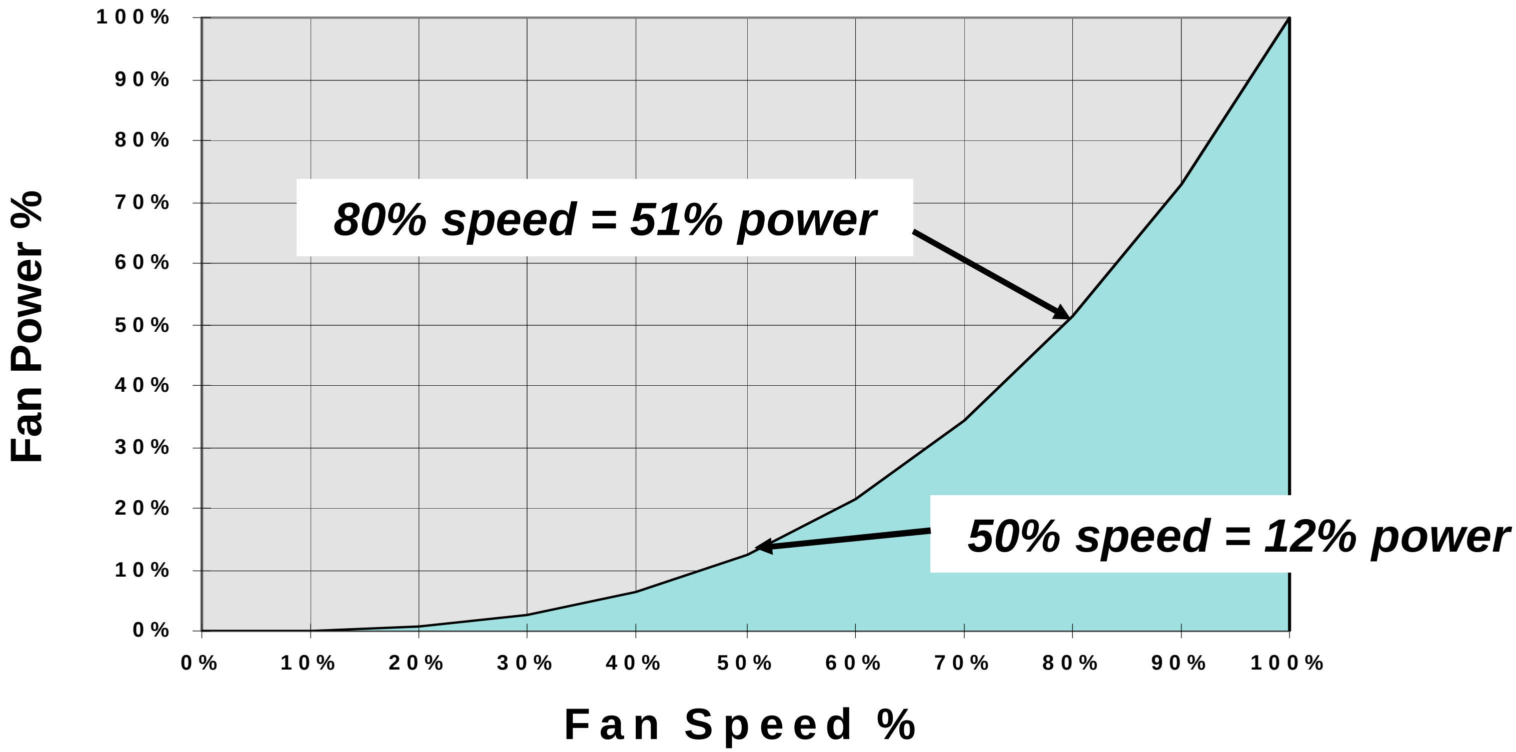
Fixed head pressure



Floating head pressure



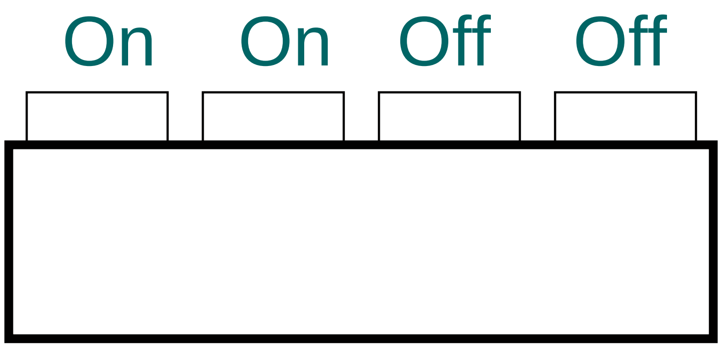
Variable speed fan control – third power relationship



Capacity varies directly with change in airflow

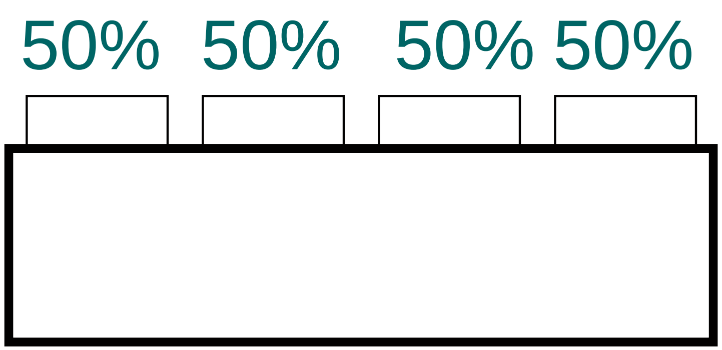
Fan power varies with <u>cube</u> of change in airflow

Part load condenser performance
variable speed vs. fan cycling



50% capacity
50% power

80 BTUH/Watt



50% capacity
12% power

330 BTUH/Watt

Specific efficiency increased by 300% with variable speed

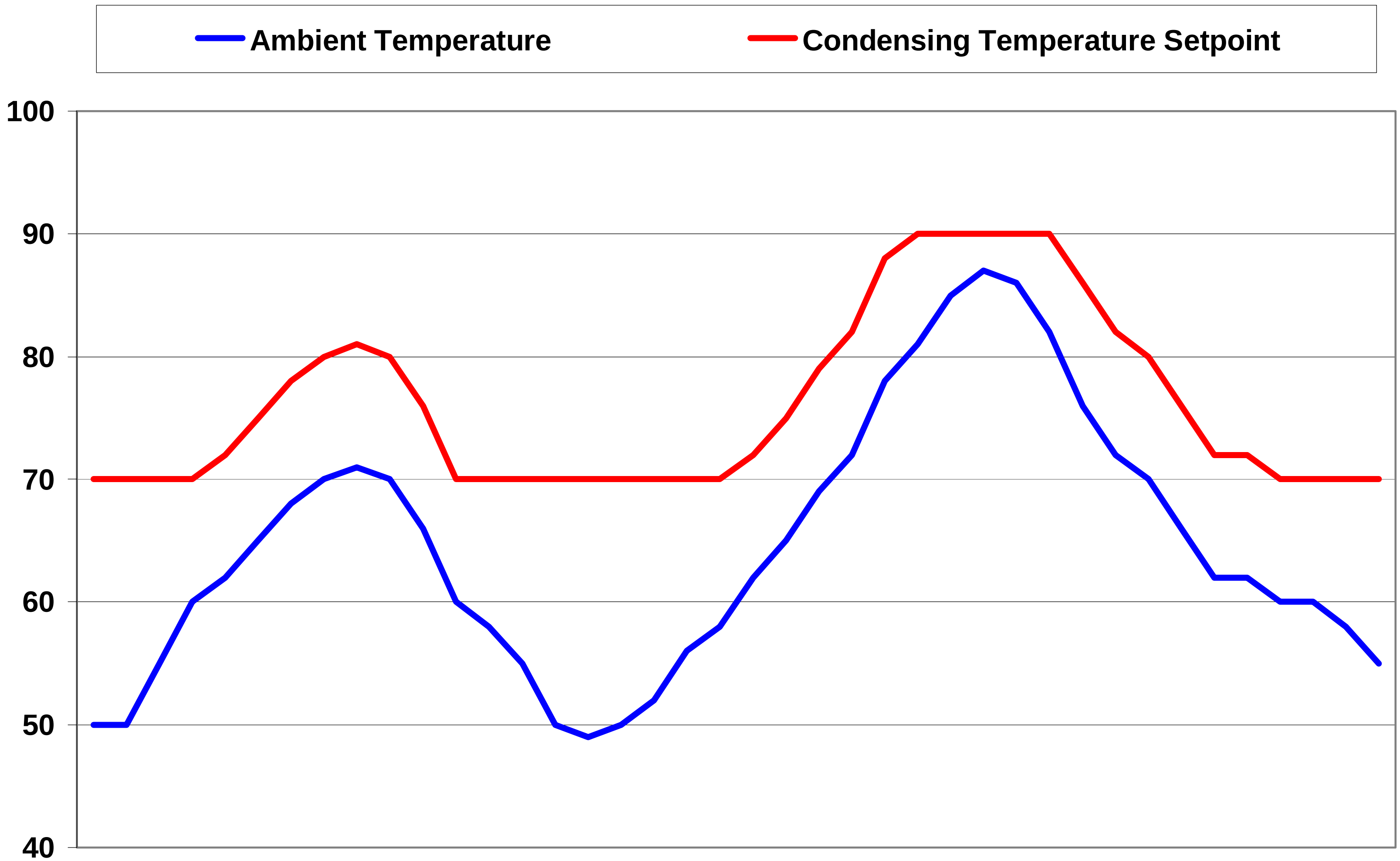
Floating head pressure
common challenges

- Large benefit even in moderate climates
- No brainer? Why not more widely adopted?
- Potential and/or perceived problems:
  - may require more refrigerant charge
  - erratic system operation, liquid feed problems
  - system has too much capacity (at wrong time)
  - oil separator velocity
  - Defrost/ice harvest problems
- Problem often NOT lower pressure itself, rather the effect of larger fluctuations
- Requires understanding overall system design and engineering considerations

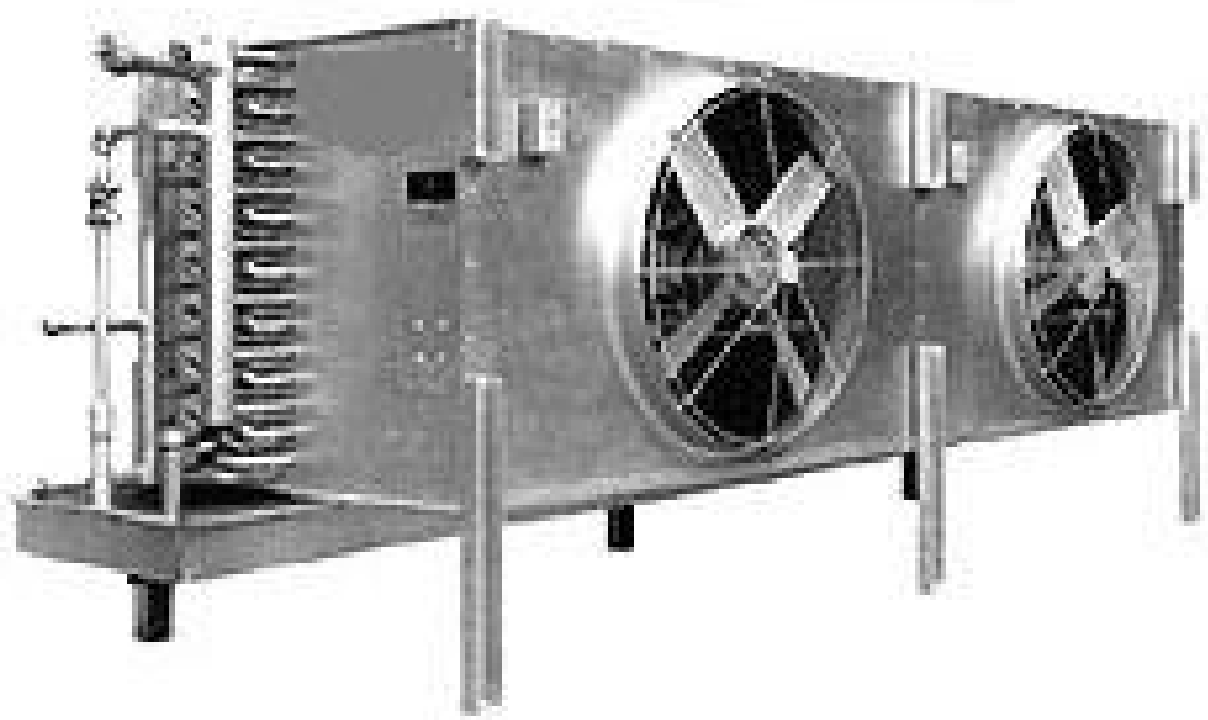
Integrated heat rejection control – floating head pressure successfully

- **Condenser fan control, including:**
  - variable speed fan
  - variable setpoint control (change setpoint with weather)
- **Floating head pressure**
  - savings with lower head pressure
  - savings with steady head pressure
- **Standardized approach**
  - consistent hardware configuration
  - consistent strategy
  - consistent back-up operation
- **Must be serviceable and understandable**

Variable setpoint FHP



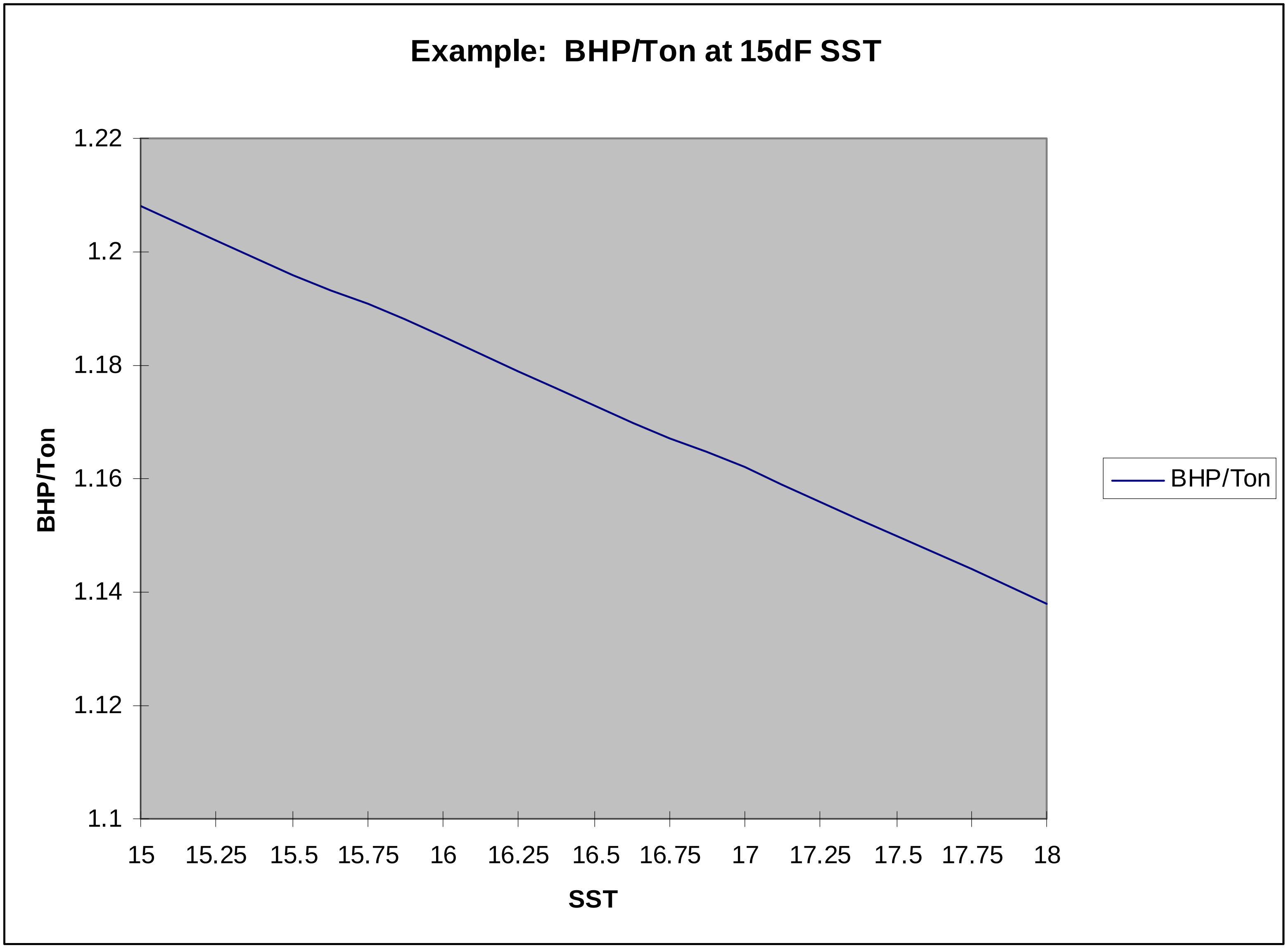
Air Unit Capacity Control



Floating Suction Pressure

- **Use your lowest temperature room as the control point.**
- **Use PID loop: As the temperature approaches the setpoint, incrementally raise the suction setpoint until stablized. If the temp goes above setpoint, slowly lower the SSP.**
- **Saving in:**
  - Compressor loading due to increase efficiency
  - Reduces temperature variations
- **Make small changes, long intervals**
- **Excellent for storage warehousing**

3dF Maximum Float: Average Efficiency Gain of 2.9%



Variable volume variable temperature air unit control

- **Vary fan speed in freezers and coolers as primary means of temperature control**
- **Saving in:**
  - Fan energy
  - Refrigeration cooling load (at high kW/Ton)
- **Third power rule applies to fan power**
- **Reduce speed to 60-70% <u>then</u> float suction**
- **Typical concerns and response:**
  - Motors burn up: *use right motor, don't run too slow*
  - Air falls on the floor: *education, don't run too slow*
  - Coils won't feed, won't defrost: *don't run too slow, try it*
  - *Not good for rooms with high product pulldown req.*

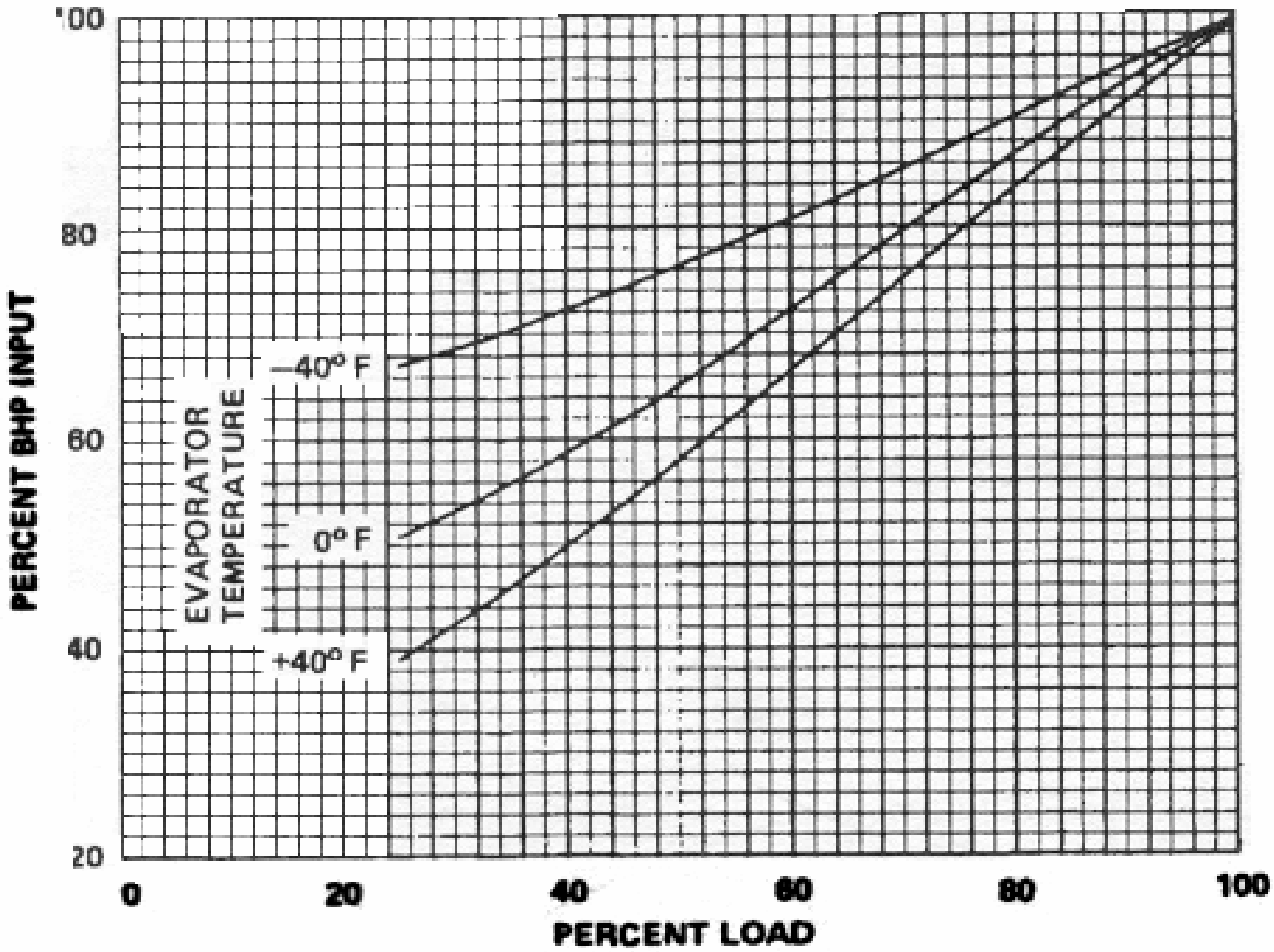
Variable Speed Screw Compressor Capacity Control

Variable speed screw compressor control

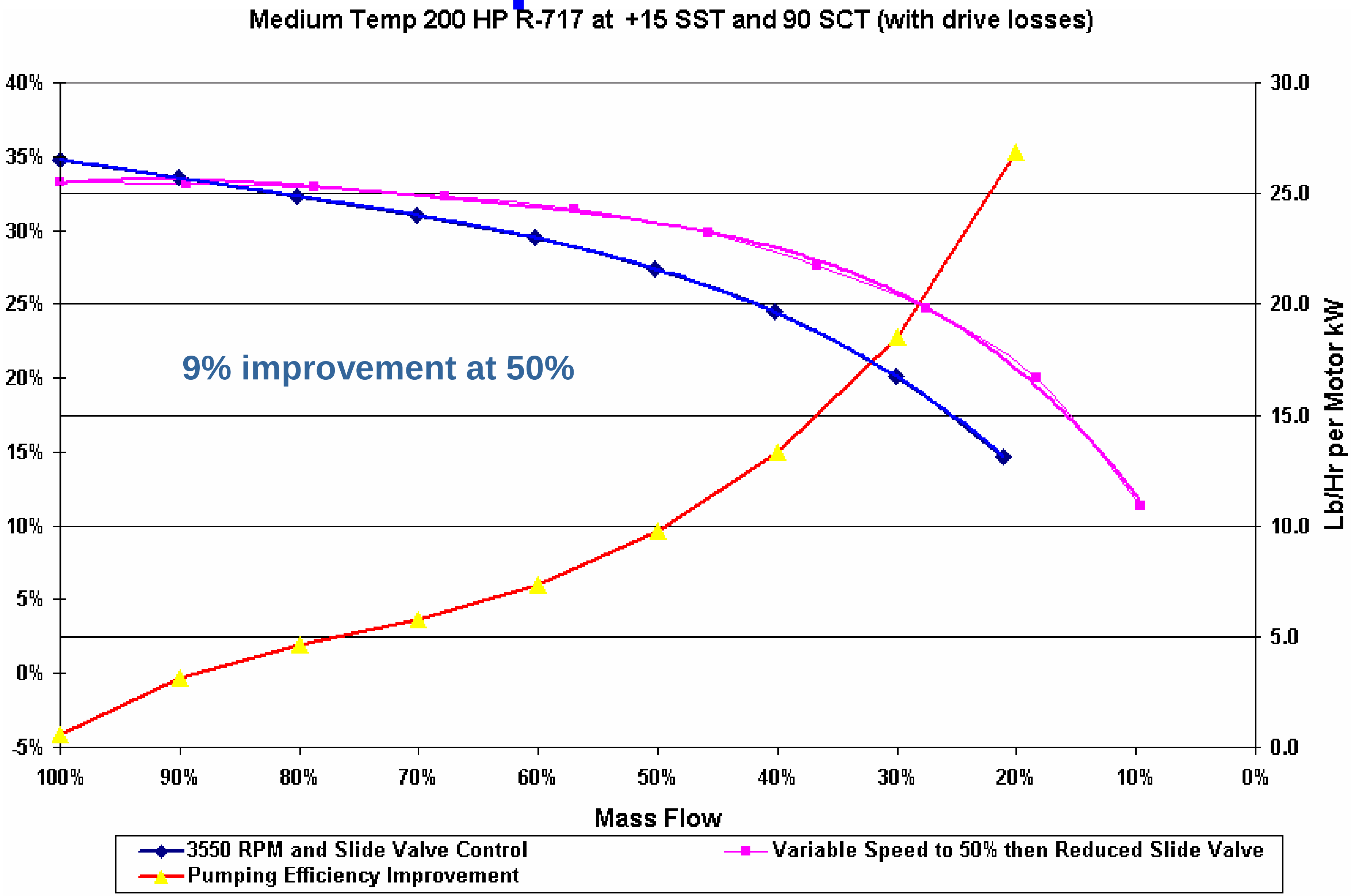
- **Application does <u>not!</u> follow third power rule**
- **Minimum speed: approx. 50% (Frick = 20%)**
  - Use slide valve below 50%
- **Losses:**
  - Increased leakage due to lower tip speed
    - Minimal losses, based on manufacturers software
    - Varies with application condition
  - VFD losses: fixed and variable components, ~4% total
- **Savings:**
  - Depends on time at reduced capacity
  - Requires adequate control sophistication (overall plant)
  - Manufacturers data varies <u>A LOT</u>

Capacity vs. BHP at part load

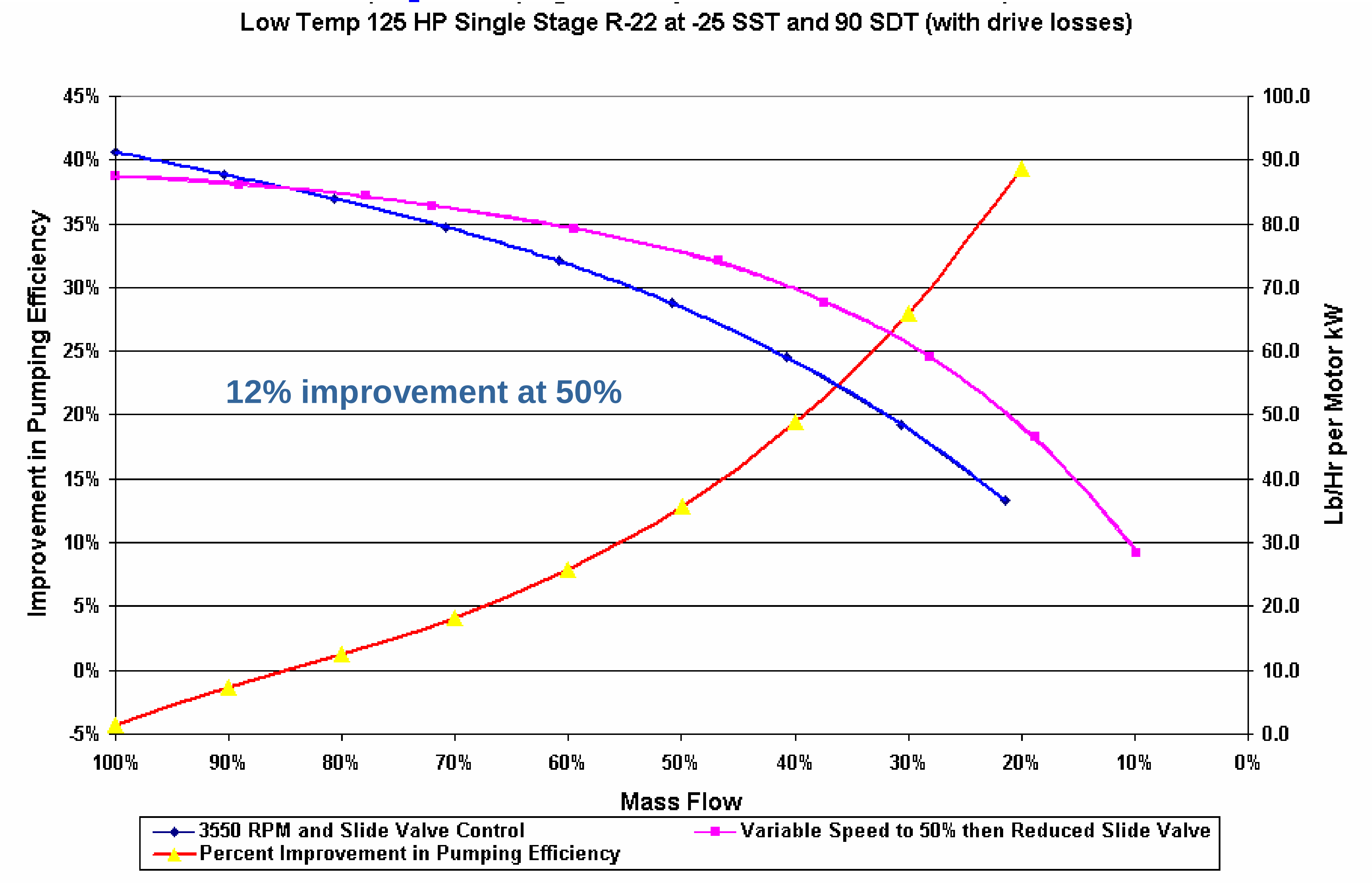
TYPICAL PART LOAD POWER INPUT WITH CONSTANT CONDENSING TEMPERATURE - HIGH STAGE



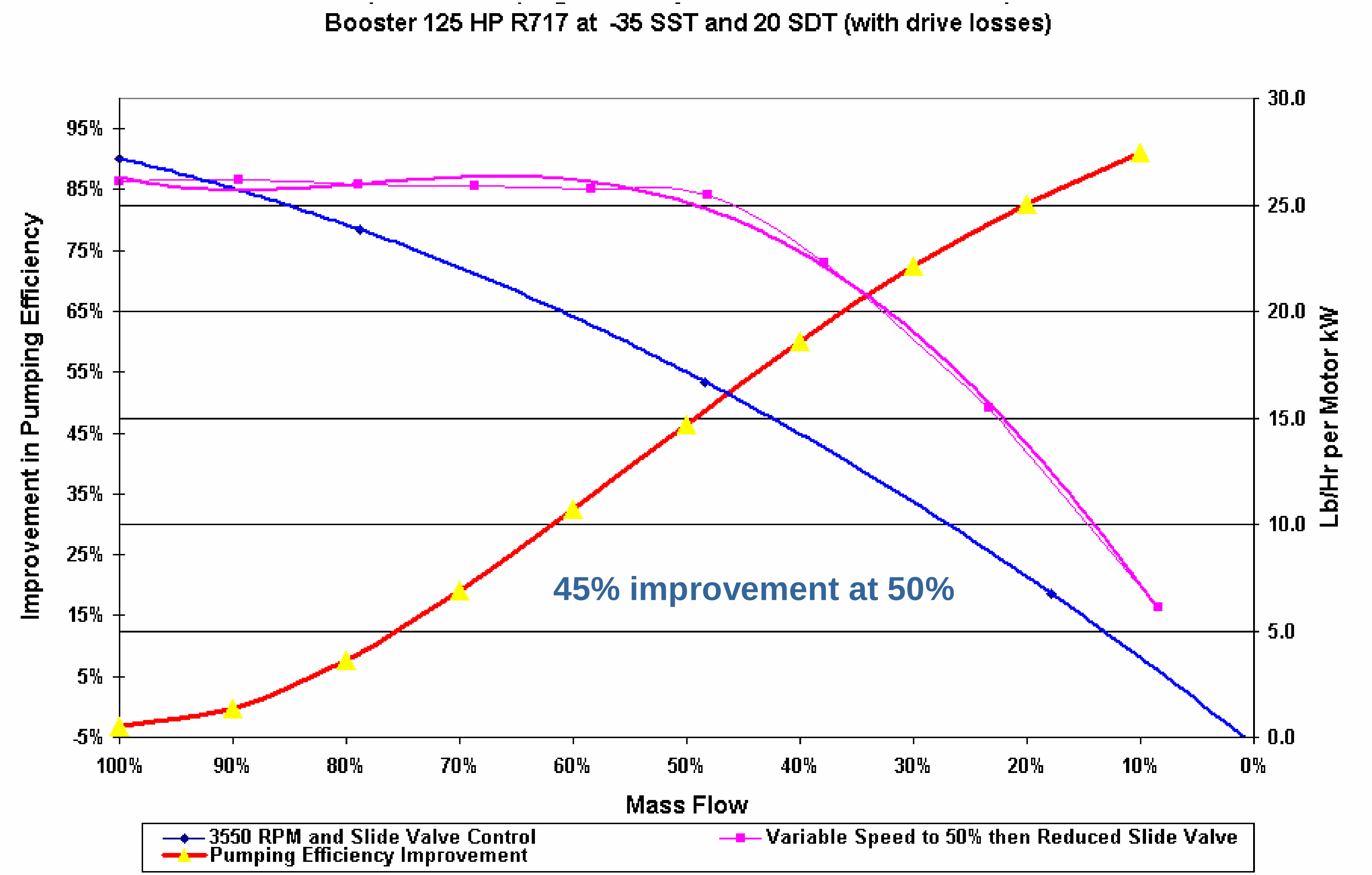
Medium temp VFD vs. slide valve



Low temp VFD vs. slide valve



LT booster VFD vs. slide valve



Compressor Control Strategies

- **Study the capacities and efficiencies of each compressor on a suction group.**
- **Bring on compressors that result in the smallest increment of capacity while maintaining 80% slide valve or more on the running compressors**
- **Unload in the same fashion**
- **In high demand areas, use offset suction pressure during the day, lower at night**

Demand Control in Industrial Refrigeration

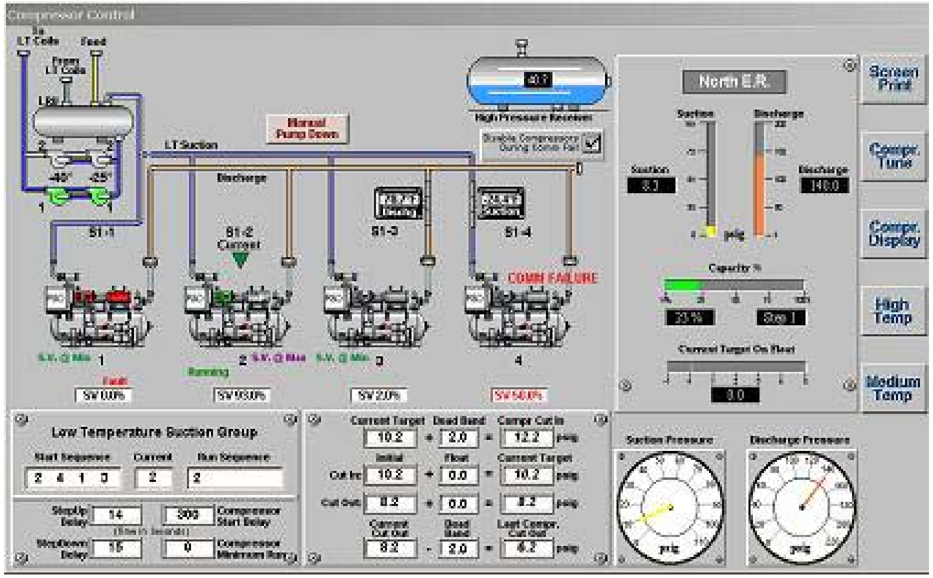
Demand Management Issues

- Lower consumption (kWh) lowers demand (kW) passively.
- Active Demand Control will likely increase consumption.
- Dollar Savings Opportunities primarily during Peak Demand.
- Demand Costs vary by Utility and Rate Structure.
- Primary Benefit during Summer Months (June-October).
- Requires Active Schedule Change or Multiple Dated Control Screens.
- Demand Shifting vs Demand Control
- Some Experimentation Involved.
- User Specific. Must be Customized.
- Not Everyone can Benefit.

Demand Reduction Opportunities May Be Very Limited

- Three Shift Manufacturing Plants
- Process Production Plants
- Inadequate Existing Control Systems
- Seasonal Maximum Production Coincides with Peak Rates
- Insulated Envelope or Infiltration Loads Too Great
- Temperature or Humidity Requirements Too Stringent
- Limited Equipment Quantity (e.g. batteries for lifts)

Calculations:



- **Simple spreadsheet to estimate savings, generally, within 10%.**

Industrial refrigeration efficiency Looking forward/conclusions

- **Potential for improved part load performance**
  - improved load control strategies (central plants)
  - lower head pressures with optimized condenser control
  - variable speed compressor control (10-40% gains)
- **Performance information**
  - real time information – Internet based
  - tie to plant information, energy $ per production unit
  - benchmark “ideal” performance for comparison
- **Other refrigeration opportunities**
  - More focus on evaporator coil/fan performance: need specific efficiency criteria & control methods
  - smaller systems can have high performance gains

Giving you what you want:

- **Improved control and record keeping of refrigeration and temperature for OSHA, EPA, and USDA review.**
- **Reduction in plant maintenance due to lower speeds, lower compression ratios.**
- **Reduced Operating Expense = MORE PROFIT!**

$$$$