Global HVAC

Danfoss Taiwan

Cascade Controller Option

For VLT 6000 HVAC Only

VLT The Real Drive

Global HVAC

Danfoss Taiwan

Cascade Controller Option

- An option card with 4 additional form C250V relays, software, connectors etc. mounted inside the VLT
- Standard Cascade control with fixed speed and variable speed or
- Master/Slave with variable speed only selectable
- True feedback based PI(D) control
- Best Efficiency Master/Slave control

Global HVAC

Danfoss Taiwan

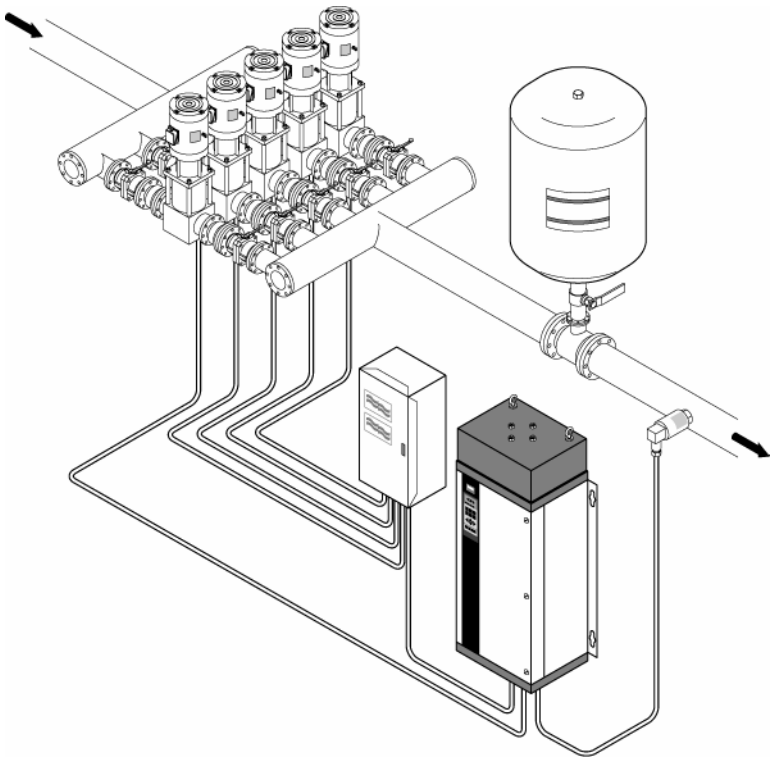
Applications

- Pressure booster sets / booster stations
- Secondary chilled water and variable primary flow pump sets
- Level controlled pumps sets
- (District) Heating Circulating pumps
- Condenser fans / cooling tower fans
- Blowers for Clarifier aeration

Global HVAC

Danfoss Taiwan

Standard Cascade Control



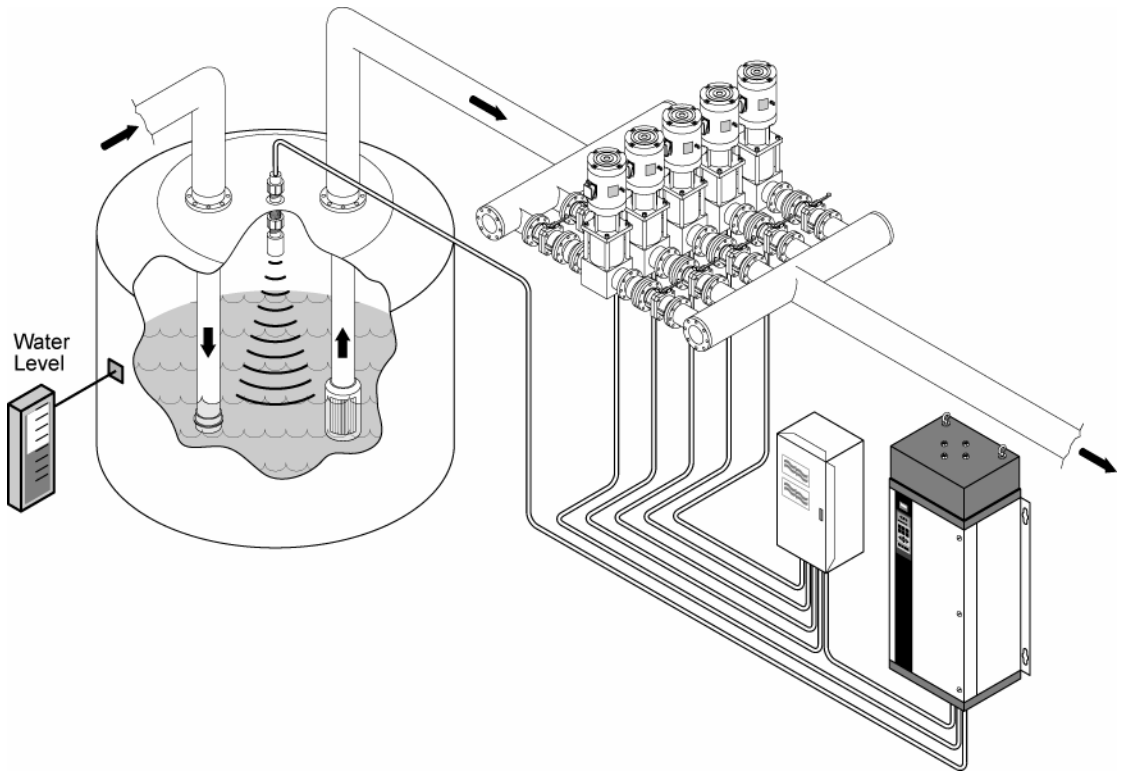
- The system consists of 1 variable speed and up to 4 fixed speed pumps/fans

VLT The Real Drive

Global HVAC

Danfoss Taiwan

Level Control



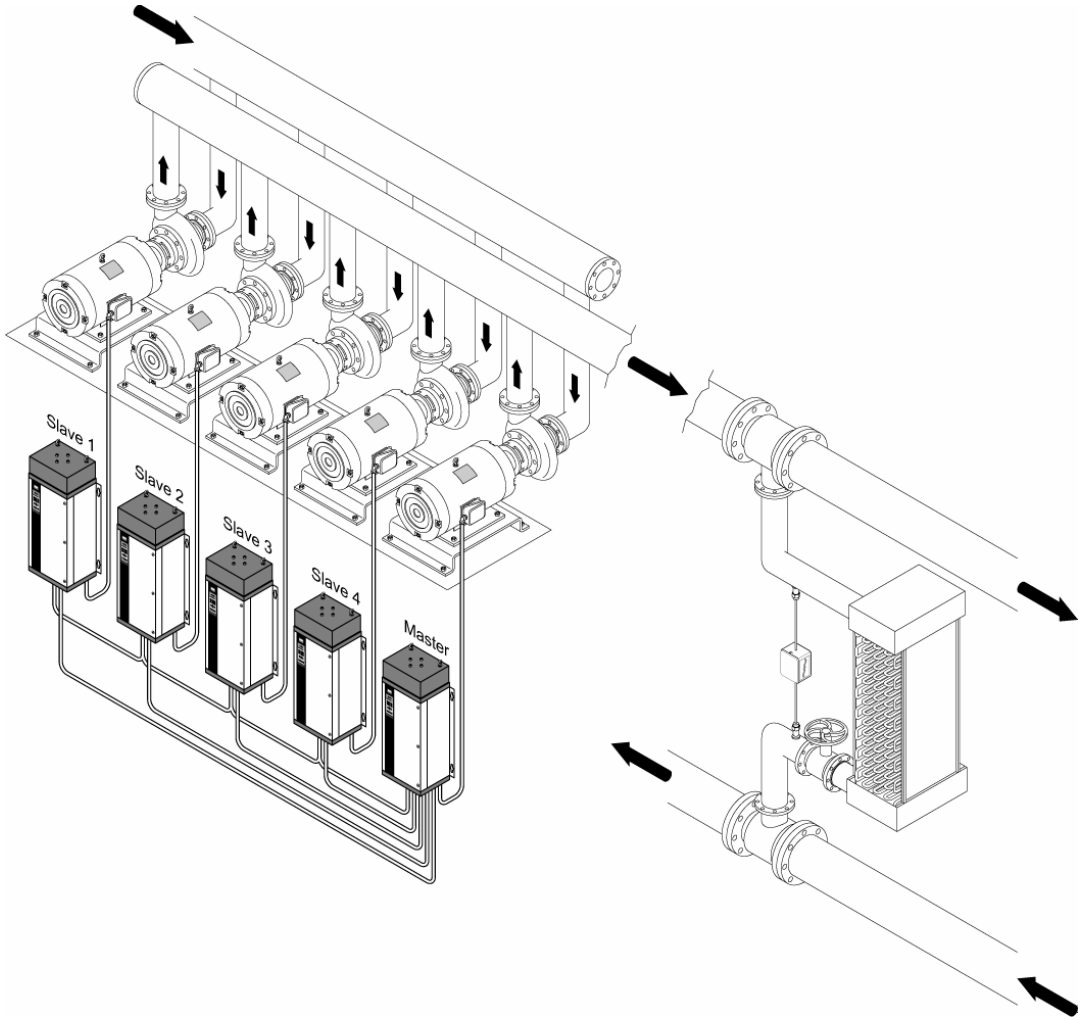
- Using the built-in PID controller allows easy inverse control

VLT The Real Drive

Global HVAC

Danfoss Taiwan

Master/Slave Operation



- All pumps or
- fans are
- drive controlled

VLT The Real Drive

Global HVAC

Danfoss Taiwan

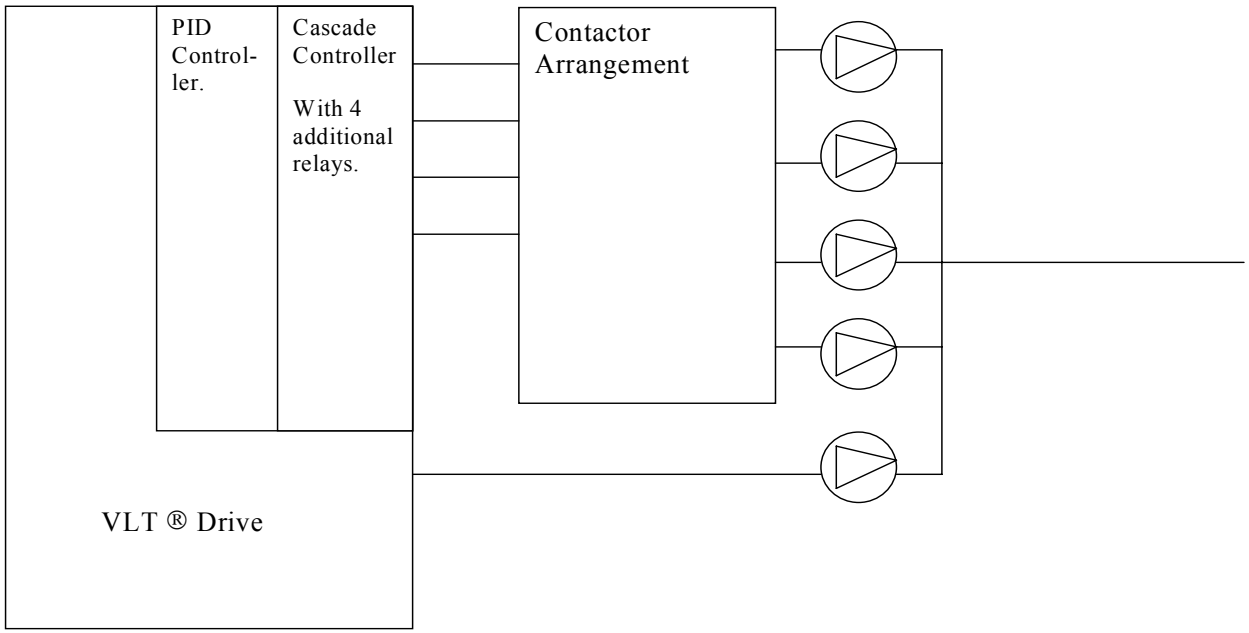
Basic System Layout

- Up to 5 Pumps or Fans
  - 1 variable speed pump or fan and up to 4 fixed speed pumps or fans in standard cascade control
    - Equal and unequal pump/fan capacity
- Operation hours dependant cycling
  - Software selectable
  - All fixed speed pumps or fans and all slaves can be cycled
  - Hours run determine which pump or fan to be switched on or off next.

Global HVAC

Danfoss Taiwan

The NEW solution



Global HVAC

Danfoss Taiwan

Capacity Combinations

Choice	Connected to the VLT (100% capacity)	No. of additional 100% Capacity	No. of additional 200% Capacity	No. of additional 300% Capacity
1	1	1 (Pump 2)	-	-
2	1	2 (Pumps 2 & 3)	-	-
3	1	3 (Pumps 2,3 & 4)	-	-
4	1	4 (Pumps 2,3,4 &5)	-	-
5	1	1 (Pump 2)	1 (Pump 3)	-
6	1	1 (Pump 2)	2 (Pumps 3 & 4)	-
7	1	2 (Pumps 2 & 3)	-	1 (Pump 4)
8	1	2 (Pumps 2 & 3)	-	2 (Pumps 4 & 5)

equal capacity

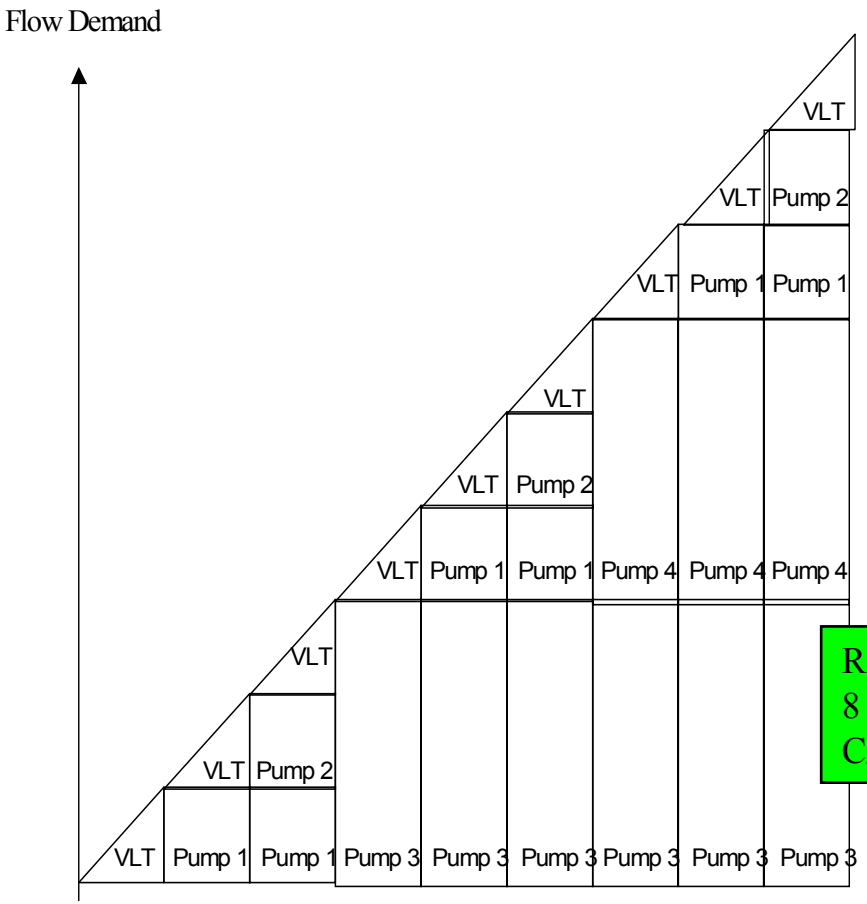
unequal capacity
(not suitable for M/S)

A predetermined pattern, will make programming easy.

Global HVAC

Danfoss Taiwan

8 pre-determined combinations



Number of stages is determined by difference between max. and min. flow requirement.

Represented here is choice no. 8 = 1 V/S (100%) + 2 x 100% C/S + 2 x 300% C/S pumps

Global HVAC

Danfoss Taiwan

PID Controller

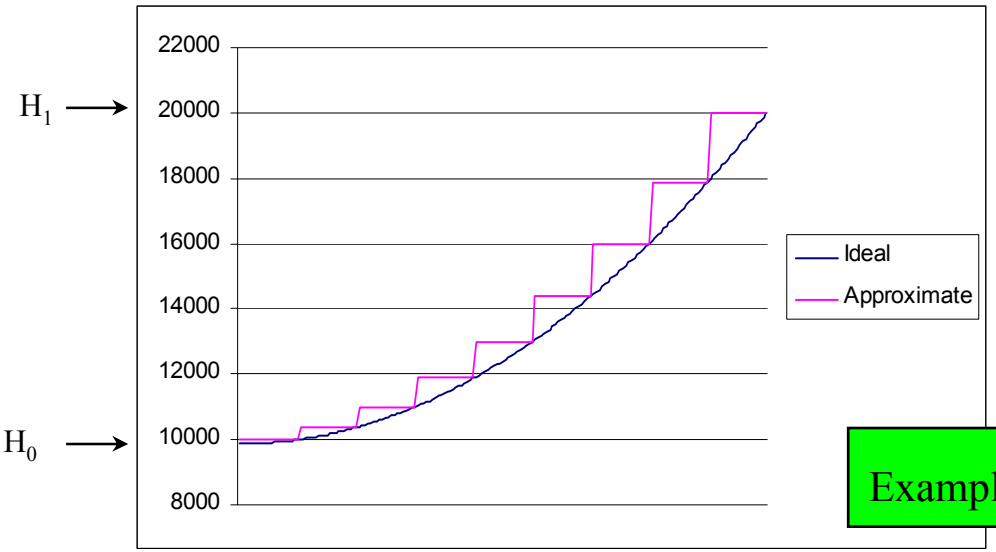
- Full functionality of the VLT 6000 HVAC built-in PID controller
  - Anti-wind up
  - Low pass filter
  - Normal / Inverse control
  - 2 feedback calculation
  - 2 zone control
  - etc.

Global HVAC

Danfoss Taiwan

Control Curve Approximation

- Standard Cascade control setpoint correction
  - H1 = Setpoint (pressure) at full capacity / flow
  - H0 = Setpoint (pressure) with the variable speed device running only.
  - Hm's = Intermediate points (calculated automatically)



H1 = H0 if sensor can be placed correctly

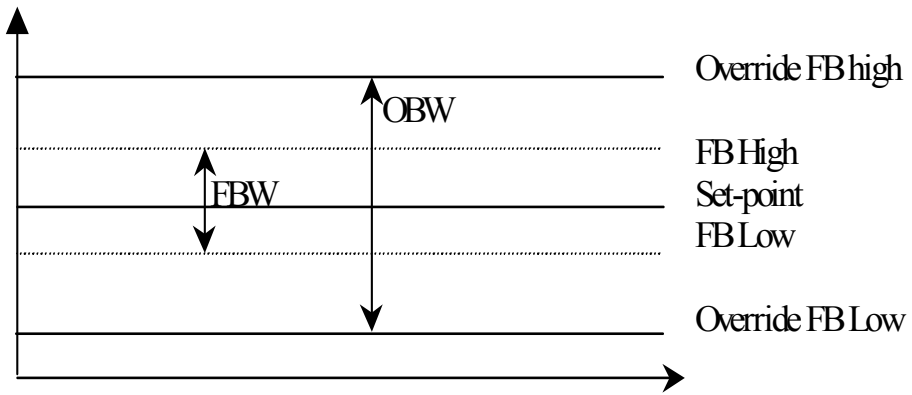
Example with 8 stages.

Global HVAC

Danfoss Taiwan

Control Bandwidth's / Timers

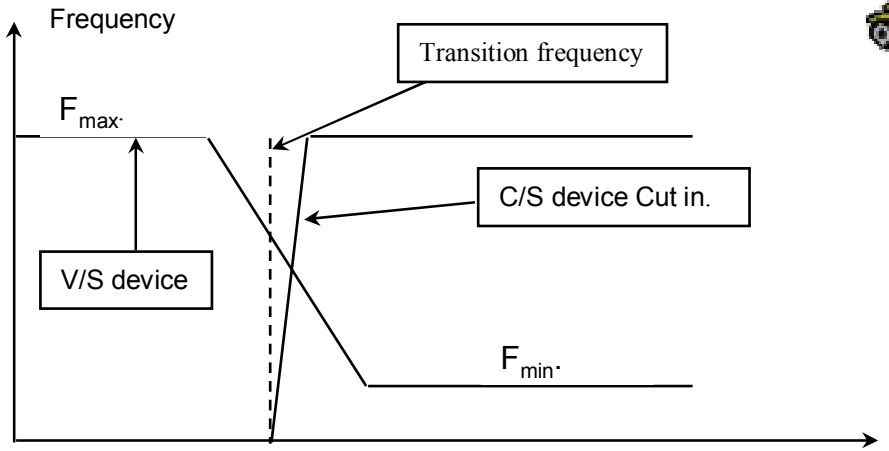
- Control bandwidth (% of set point)
  - 2 Programmable timers (ON/OFF) determine when to react on feedback to avoid frequent switching
- Override Bandwidth (% of set point)
  - A programmable timer to determine reaction time to feedback signal



Danfoss Taiwan

Transition Frequency

- It is possible to program at what frequency the constant speed pump/fan is started, when ramping down the variable speed pump/fan



De-Stage Timer

- Programmable De-stage timer
  - Like a sleep mode function but for the fixed speed pumps/fans. It switched off a fixed speed pump when the variable speed pump runs at minimum speed for a programmed time.
  - Optimized energy consumption
  - Avoids “cooking” of the pump

Global HVAC

Danfoss Taiwan

User friendly Operation

- Guided programming Structure
- Completely NEW “Quick” Menu (35 parameters)
  - First perform “Drive set-up” (= Old Quick Menu)
  - Secondly, initialize PID controller.
  - Then Set up the Cascade Controller parameters.
  - Finally, Fine tune the PID controller.
- Changed Factory Settings

Global HVAC

Danfoss Taiwan

Protected against drive tripping

- The Cascade Controller will maintain operation as a C/S controller, should drive trip.
- Redundancy is possible in a Master/Slave arrangement
  - (Designate an AUX master)

Danfoss Taiwan

Service Parameters

- Operation hour counters for each pump
  - Counts the hours for maintenance purposes
  - Resettable in case the pump is replaced
  - Reset does not affect the counters for pump cycling
- Cycle counters for each pump
  - Additional counters that count the number of start/stop for maintenance purpose
- Relay status readout
  - Allows to see on the LCP how many pumps are presently in operation

Danfoss Taiwan

Serial Communication?

- Possible to combine cascade controller with Serial communication option (N2, FLN, Profibus, LonWorks)

Danfoss Taiwan

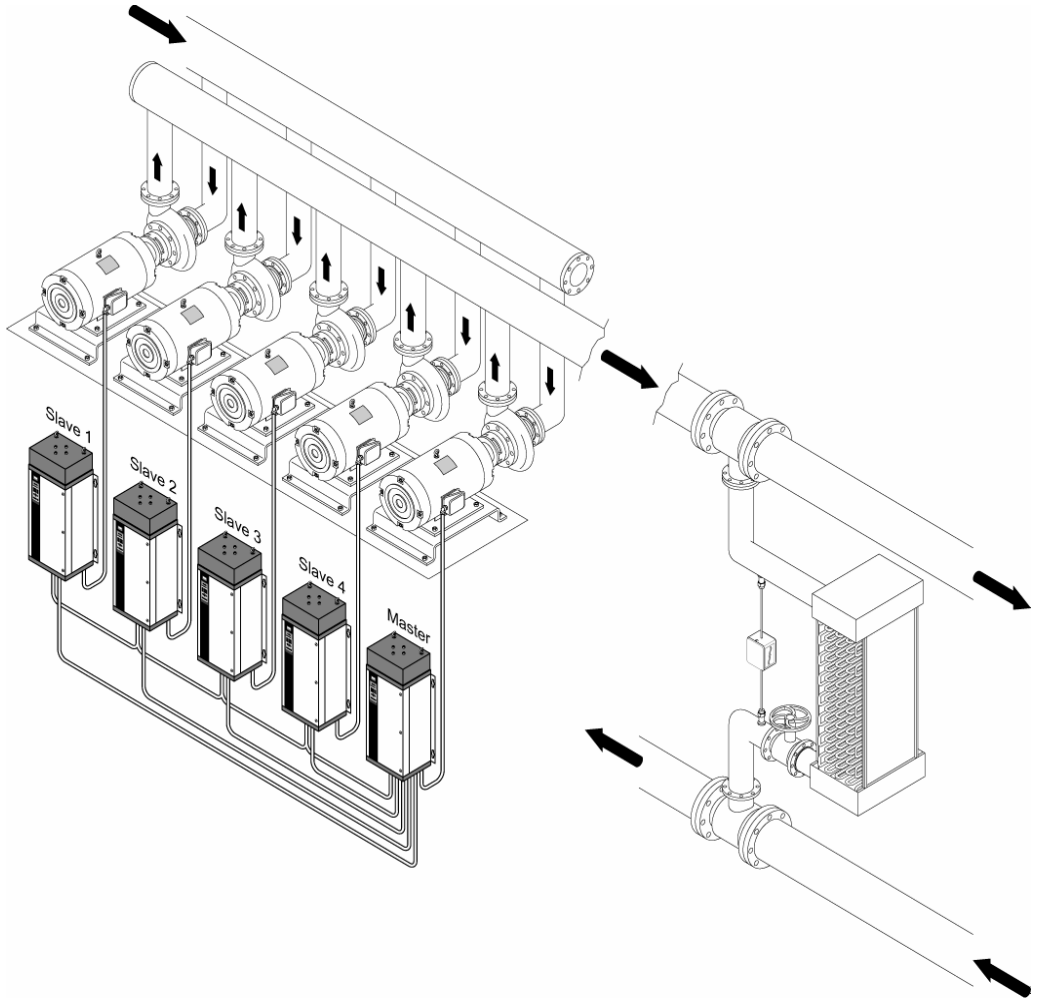
VLT® Software Dialog

- Supports the Basic (VLT 6000 HVAC) parameters.
- Will from Version 2.30-3 include the new 700 group parameters in the “Parameter Set Up” tool.
- Can not support the “Test Run / Logging modules with the present VLT(R) dialog Software.

Global HVAC

Danfoss Taiwan

Master / Slave Systems



- All pumps/fans are VLT speed controlled
- 1 VLT hosts the Cascade Controller Option, it's called the Master
- Up to 4 VLT's act as Slaves following the Masters speed reference
- All pumps/fans are of equal size
- Best Efficiency control pattern

Global HVAC

Danfoss Taiwan

Superiority of Master/Slave Control

- Less energy consumption
- Complete elimination of pressure surge and water hammer
- Accurate control to a fixed Setpoint (not within a bandwidth)

Global HVAC

Danfoss Taiwan

Master / Slave Operation

Best Efficiency Control

VLT The Real Drive

Global HVAC

Danfoss Taiwan

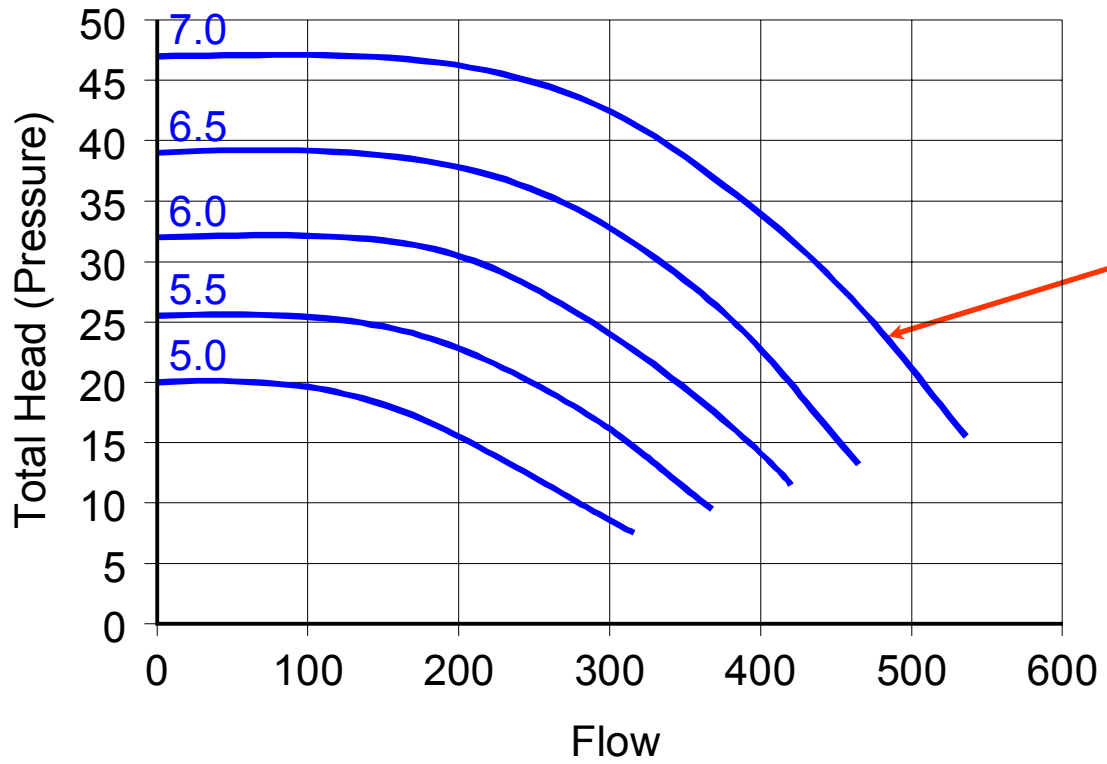
An excursion to the pumping basics

- To examine why Master/Slave is superior, we look at a “real” application
- Here we have a system design point of
  - 680 m3/h or GPM flow
  - @ 30 m or Ft. head (pressure)
- We have a setpoint of
  - 10 m or Ft. head (pressure)

Global HVAC

Danfoss Taiwan

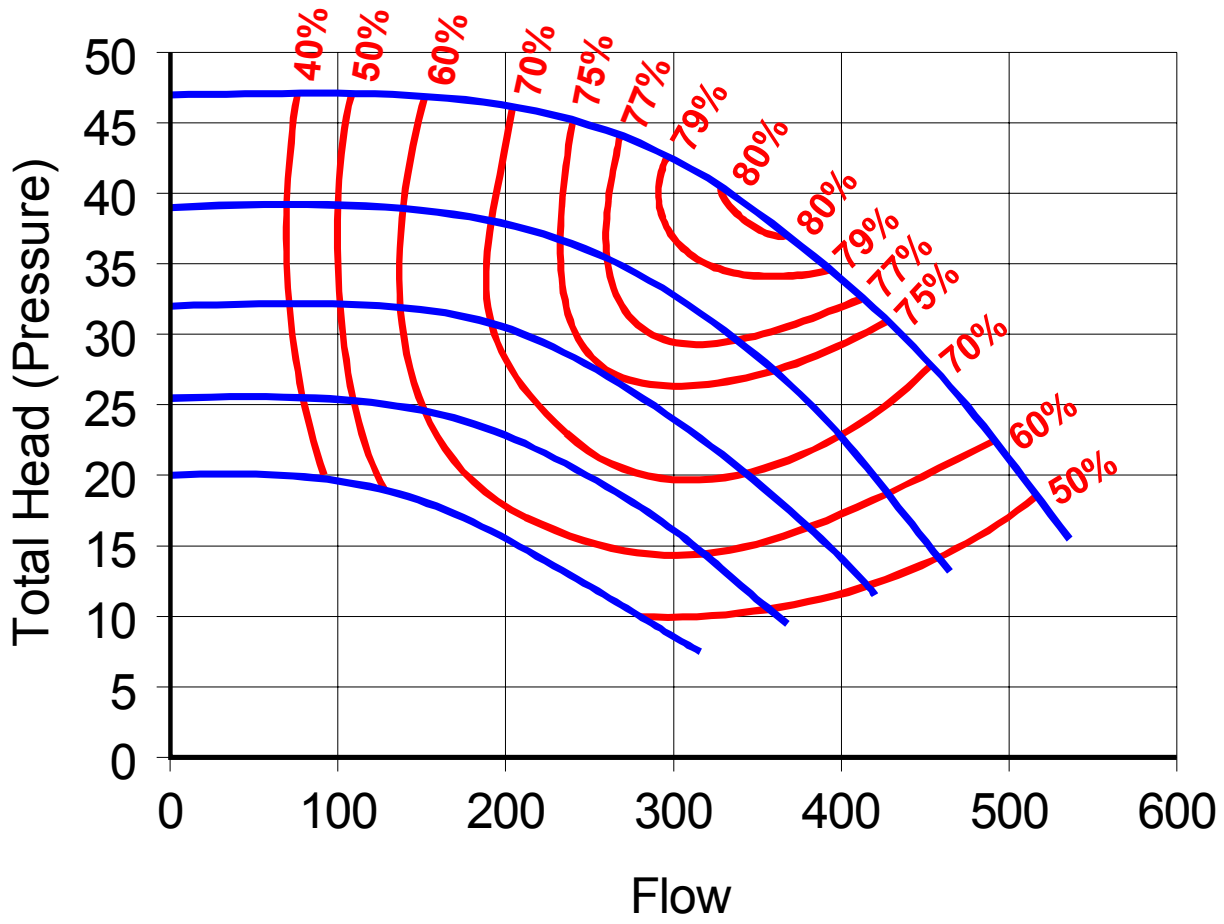
Pump Curve



Lines of different impeller diameters

Danfoss Taiwan

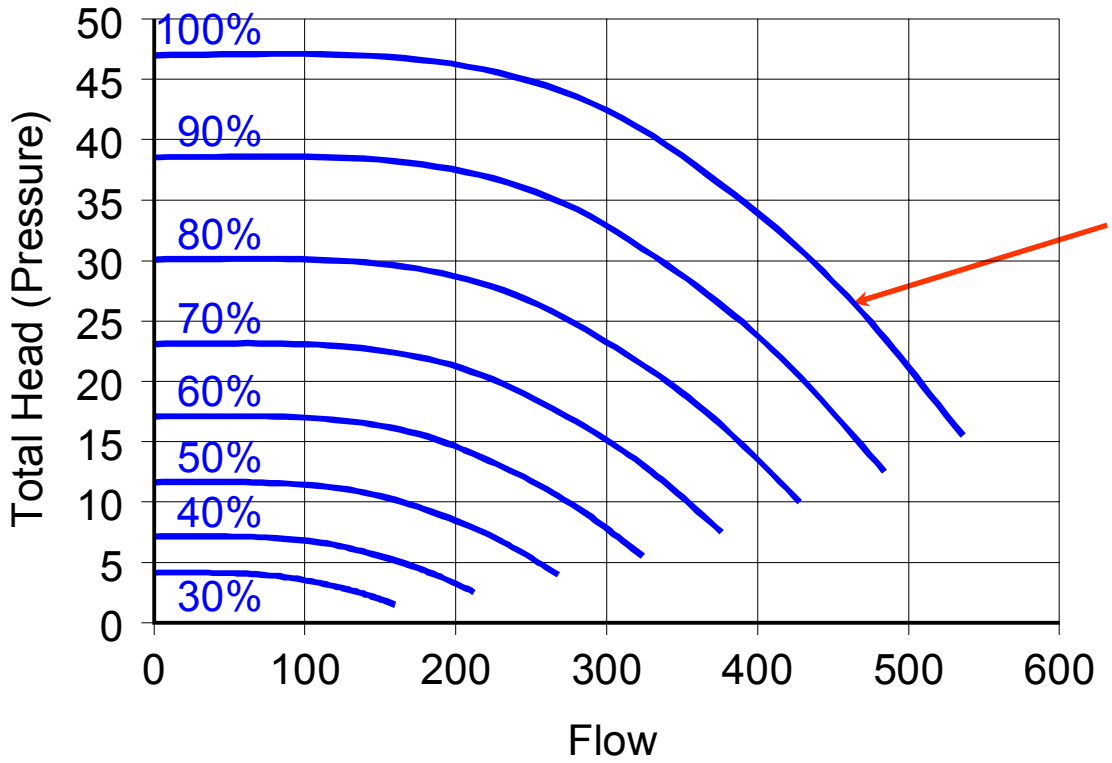
Efficiencies



Global HVAC

Danfoss Taiwan

Variable Speed

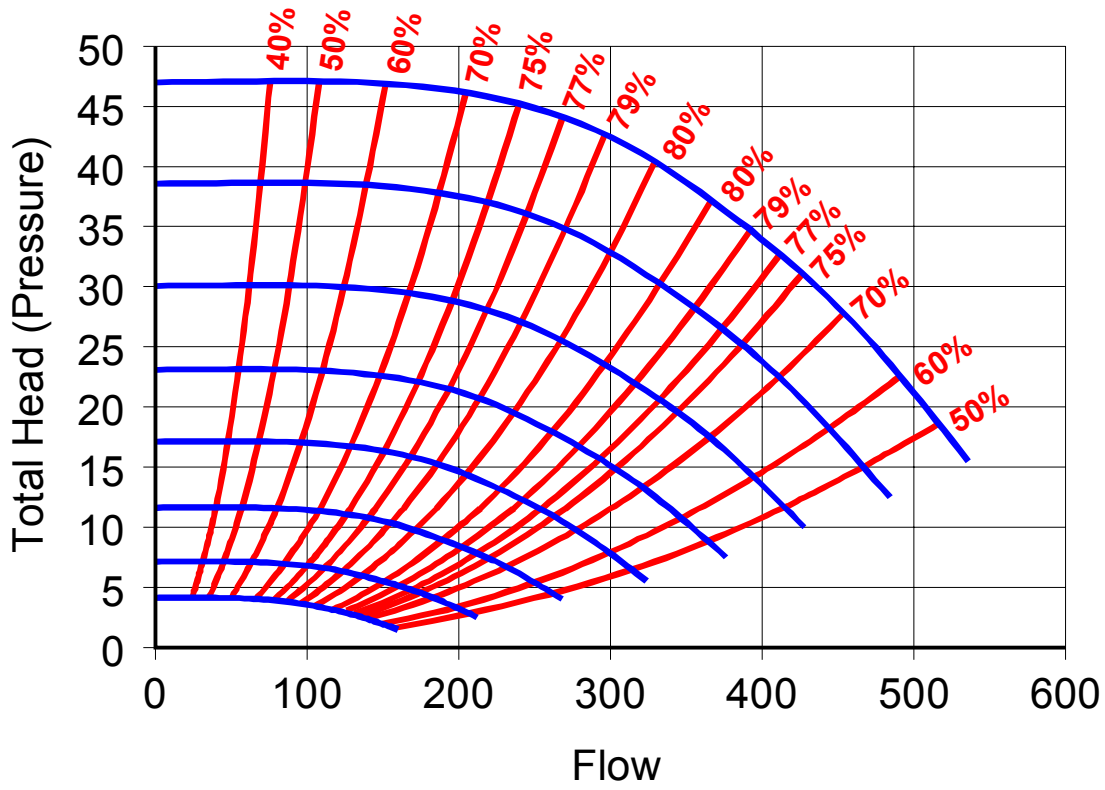


Lines of different speed

Global HVAC

Danfoss Taiwan

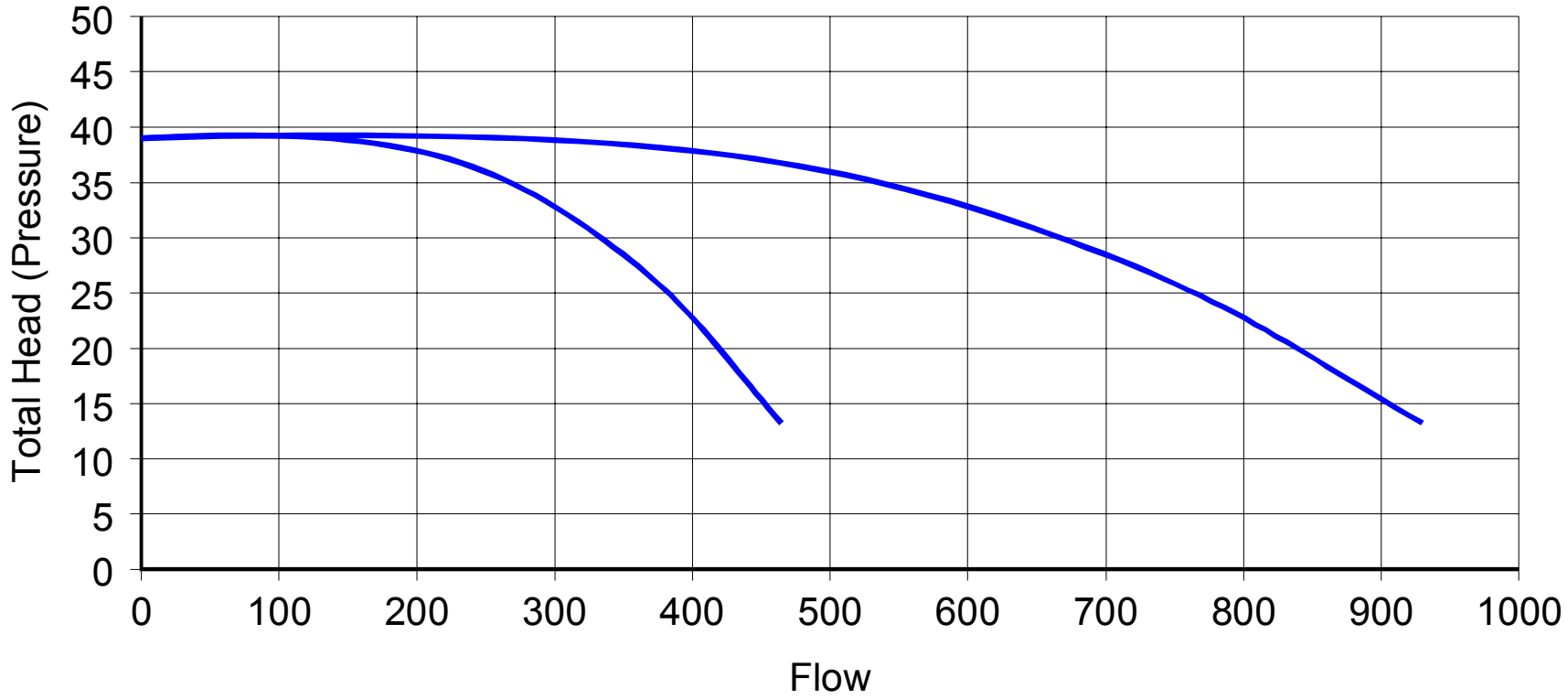
Variable Speed Efficiencies



VLT The Real Drive

Danfoss Taiwan

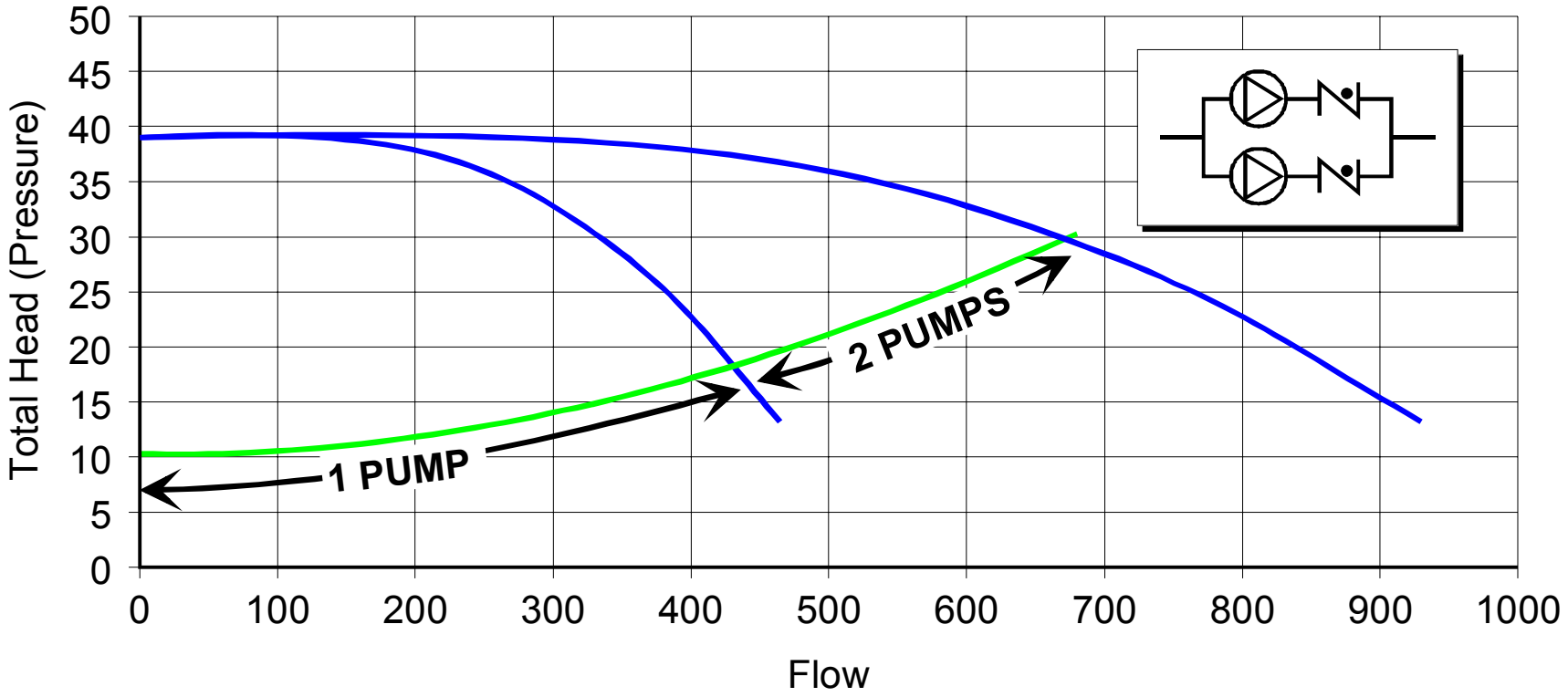
Adding a Parallel Pump



Global HVAC

Danfoss Taiwan

Traditional Staging

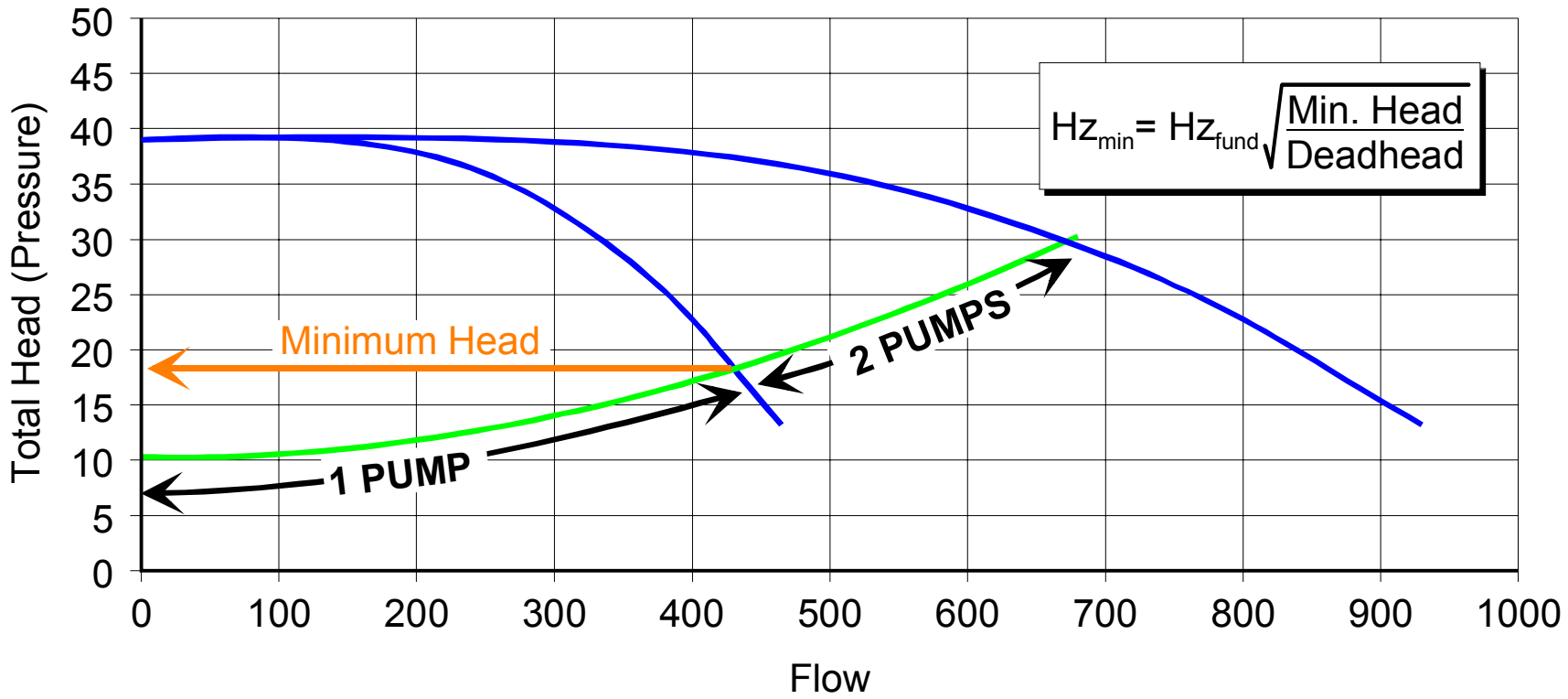


VLT The Real Drive

Global HVAC

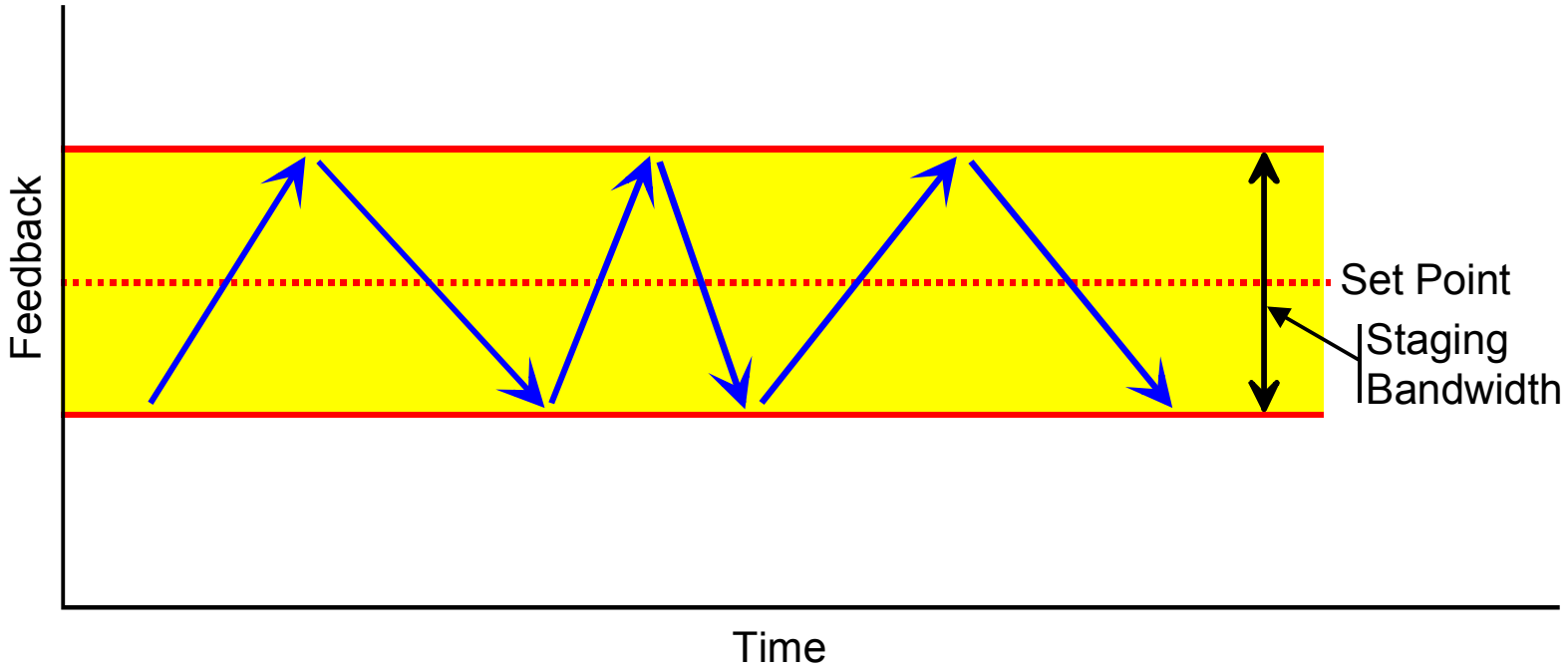
Danfoss Taiwan

Mixing Constant and Variable Speed



Danfoss Taiwan

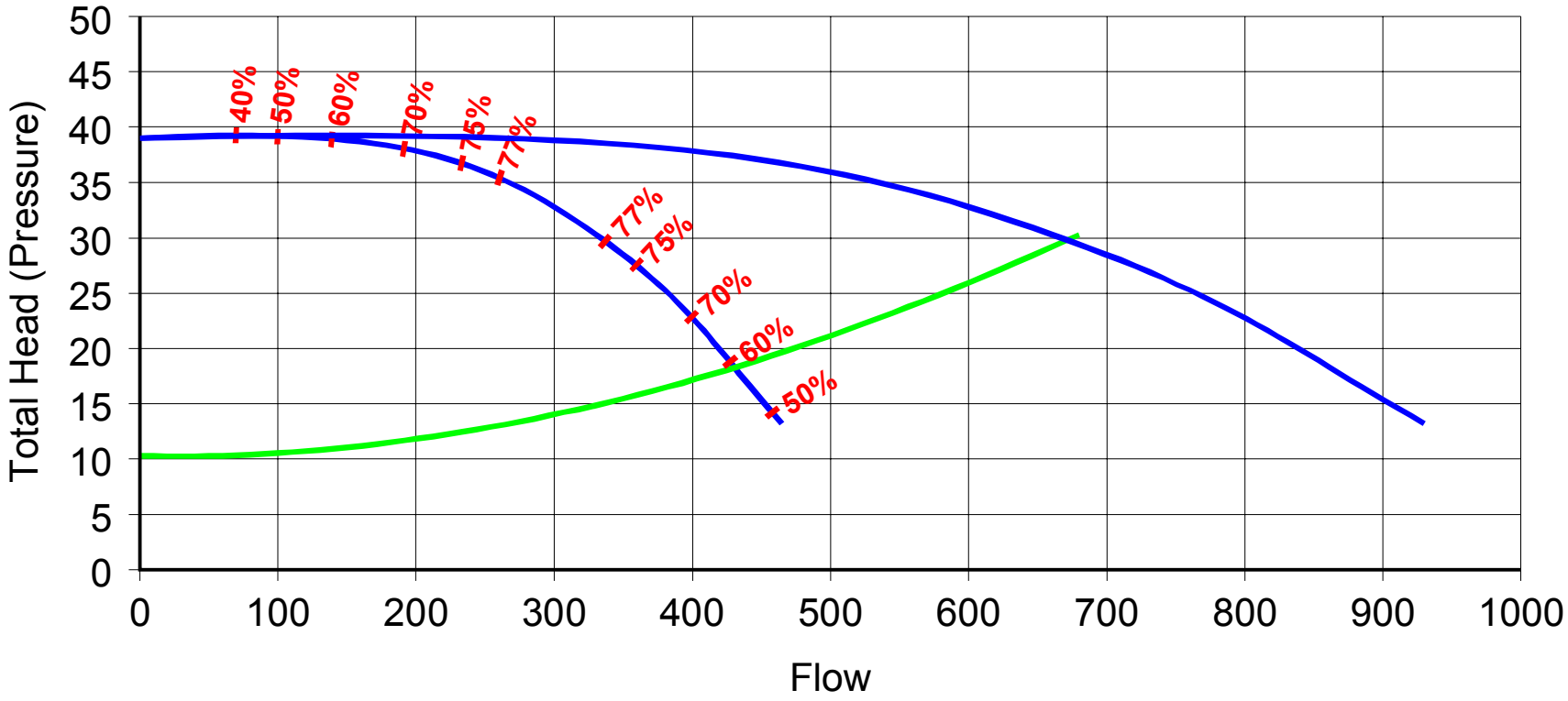
Traditional Staging



Global HVAC

Danfoss Taiwan

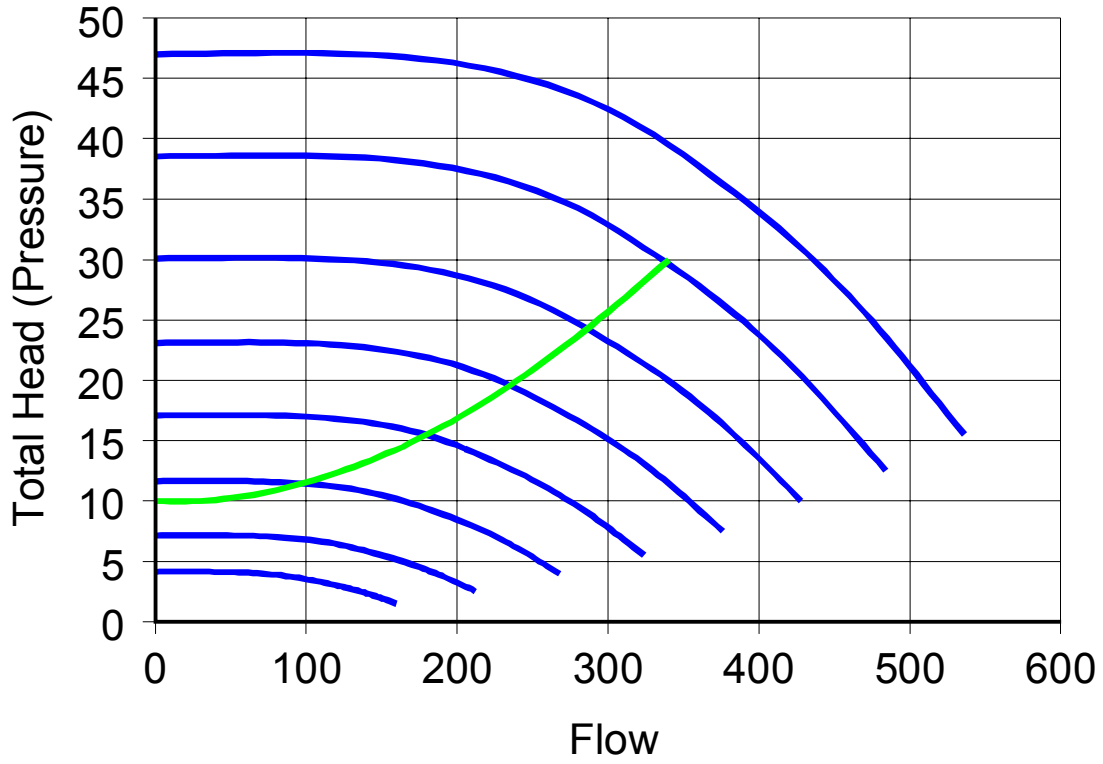
Full Speed Pump Efficiency



Global HVAC

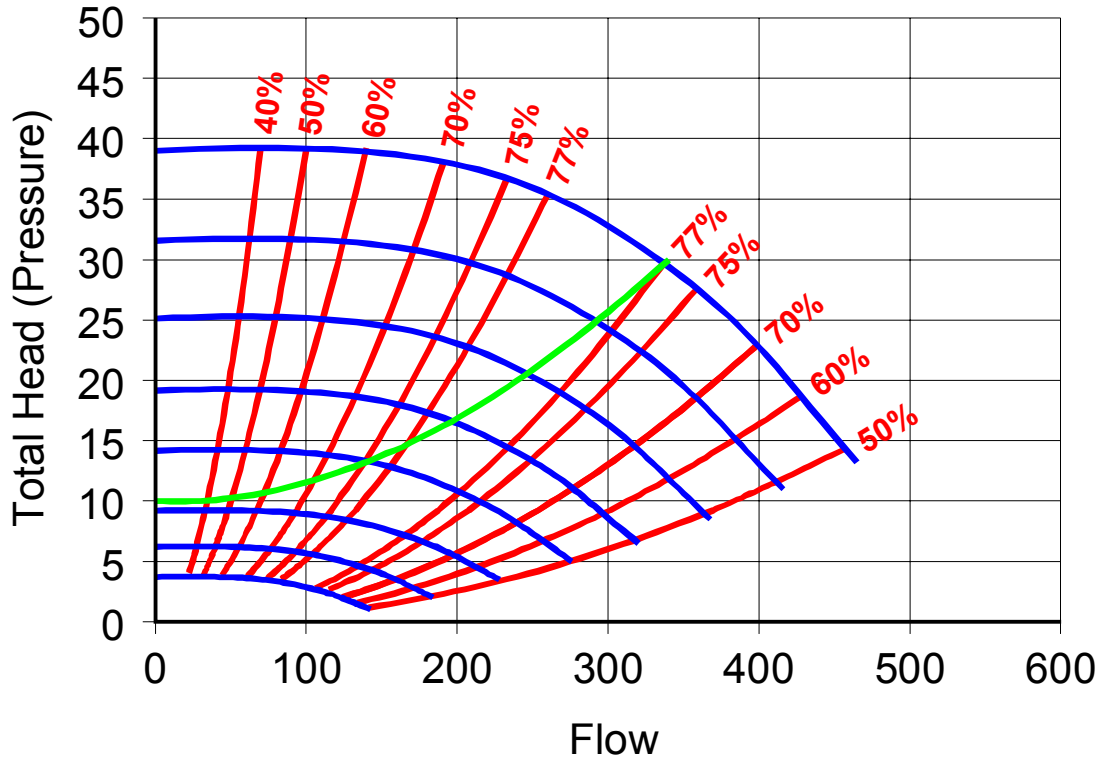
Danfoss Taiwan

Variable speed system



Danfoss Taiwan

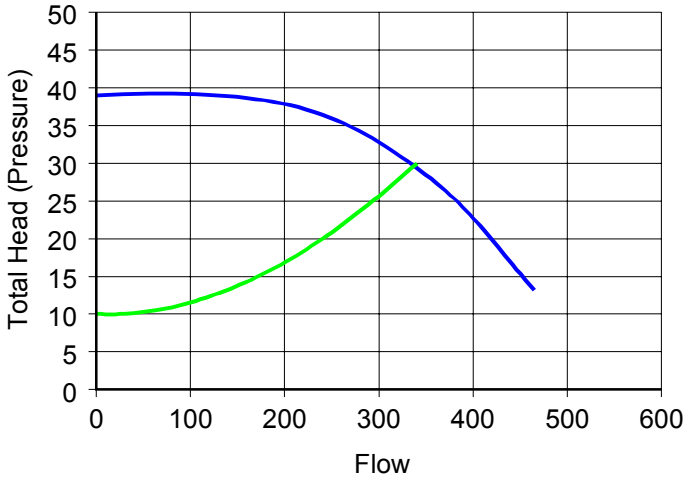
Variable Speed Pump Efficiency

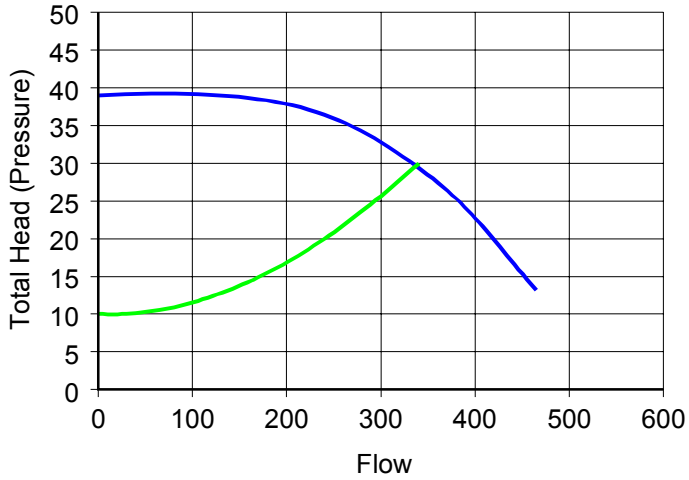


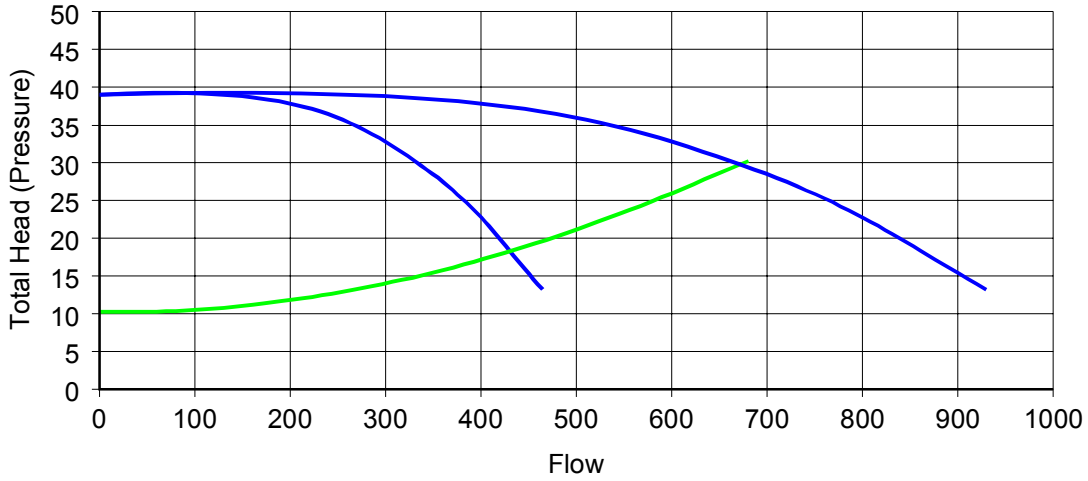
Global HVAC

Danfoss Taiwan

1 + 1 = 2



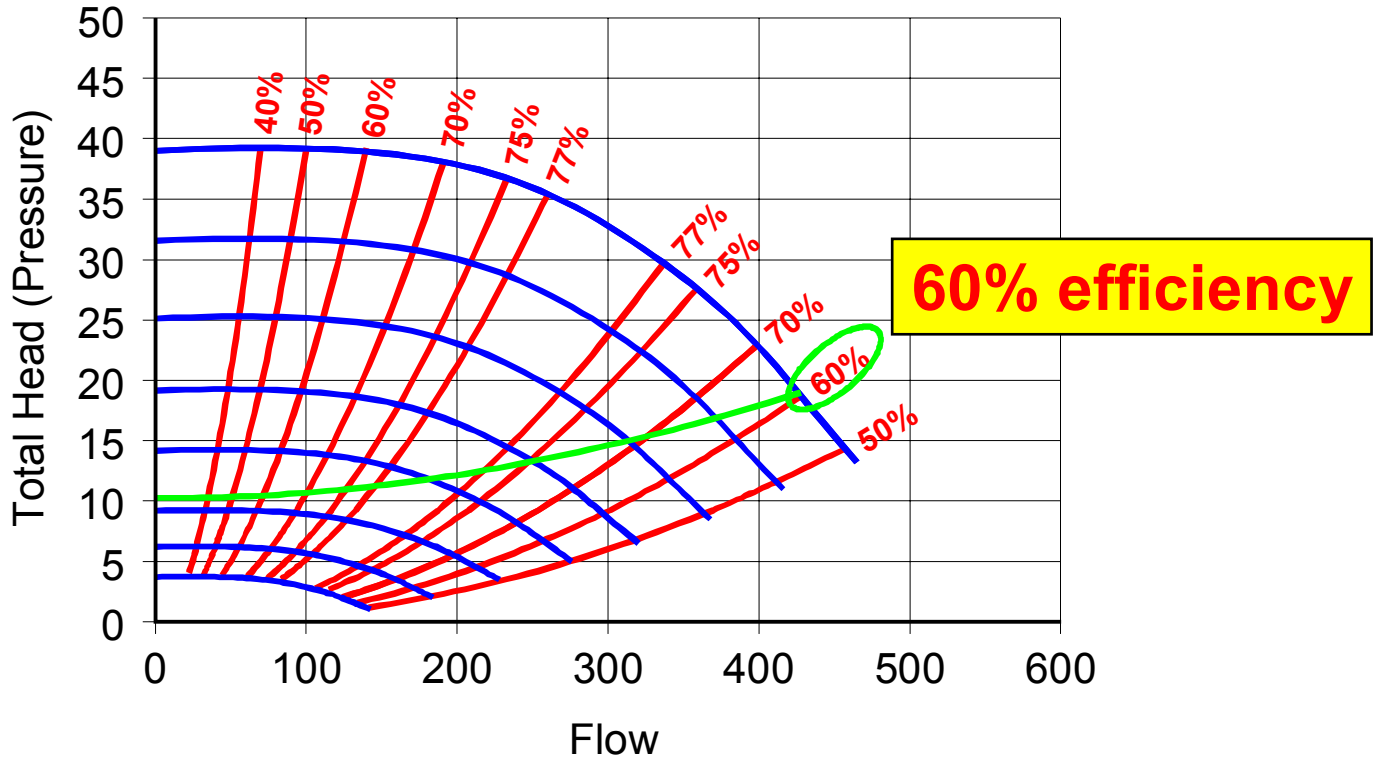




Global HVAC

Danfoss Taiwan

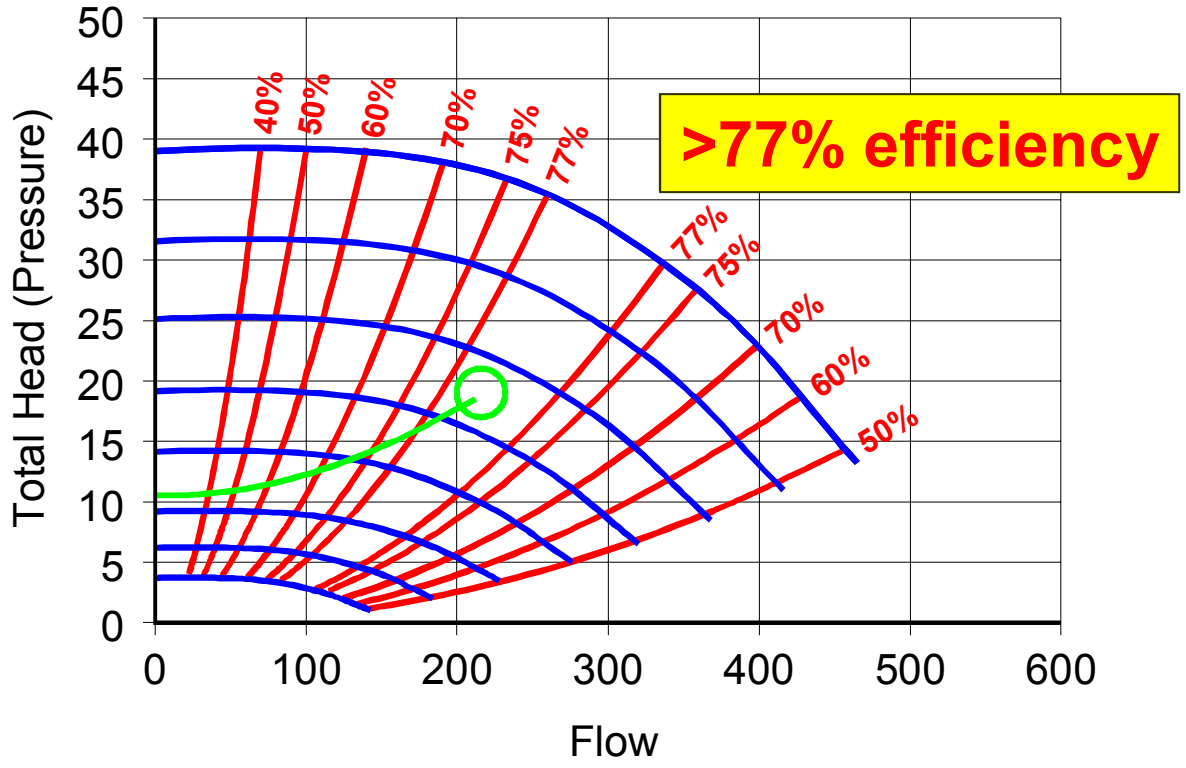
1 pump at full speed



Global HVAC

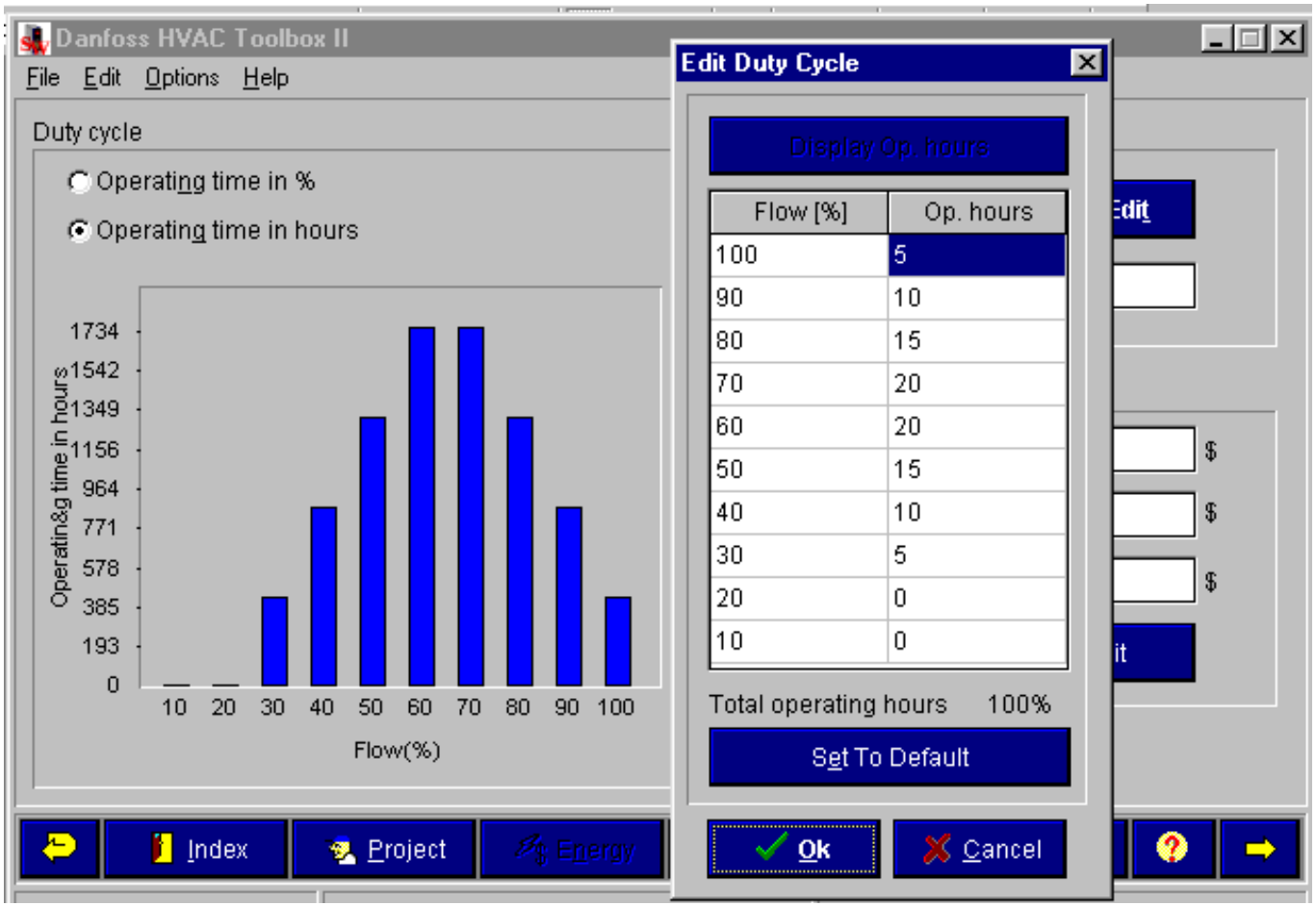
Danfoss Taiwan

2 pumps at 50% speed



Danfoss Taiwan

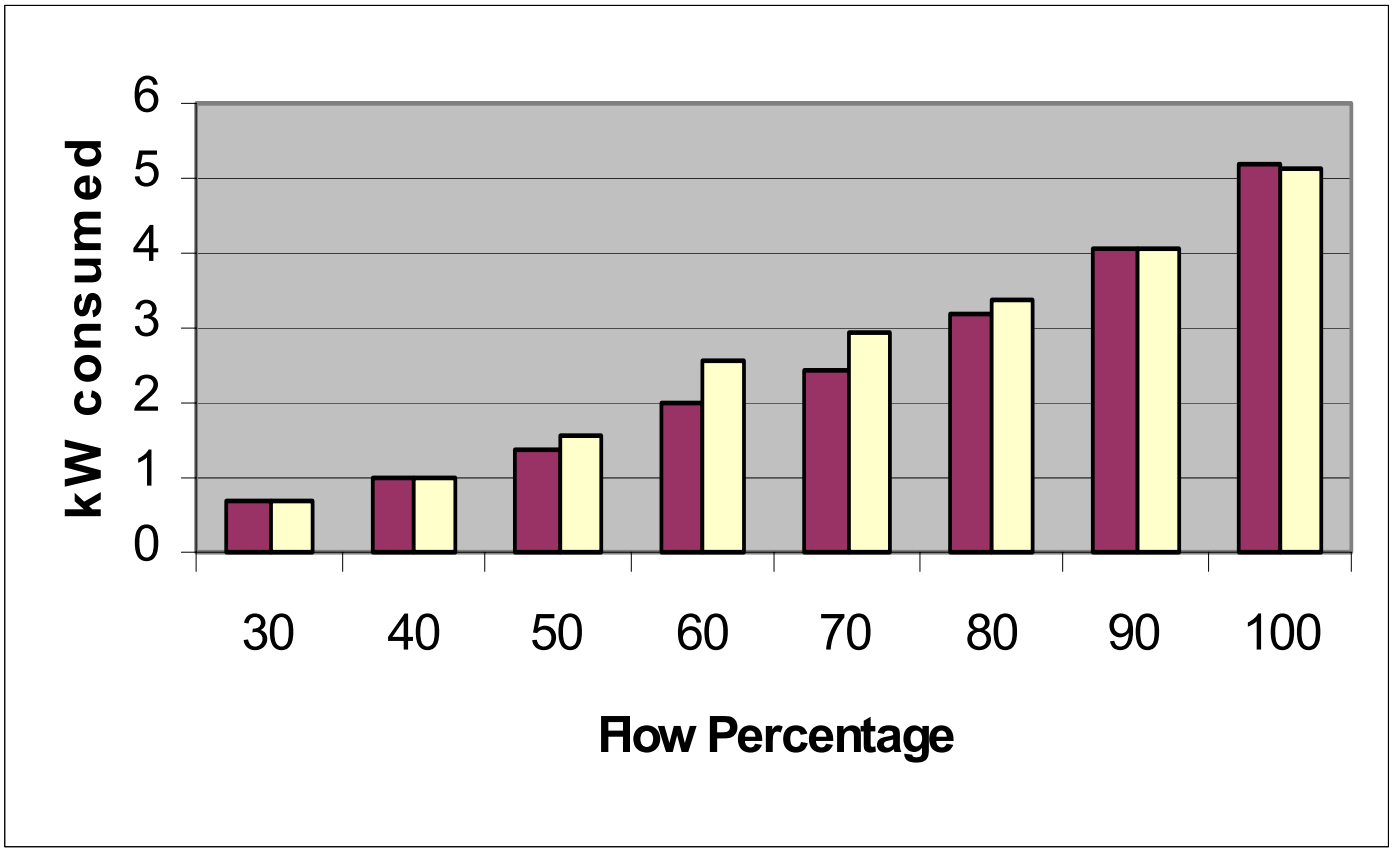
Significance



Global HVAC

Danfoss Taiwan

Comparison Study

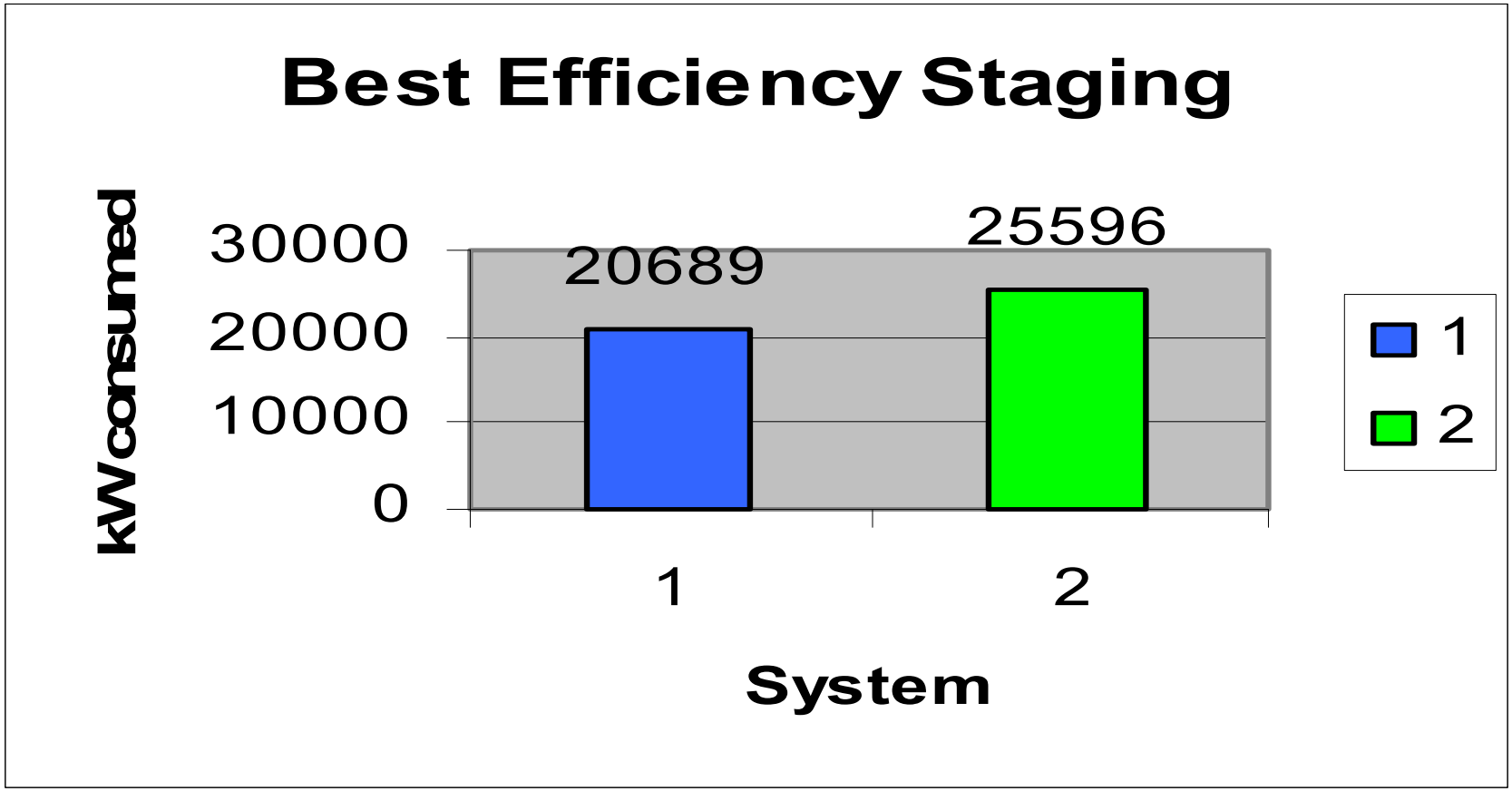


VLT The Real Drive

Global HVAC

Danfoss Taiwan

19% less kWh consumed

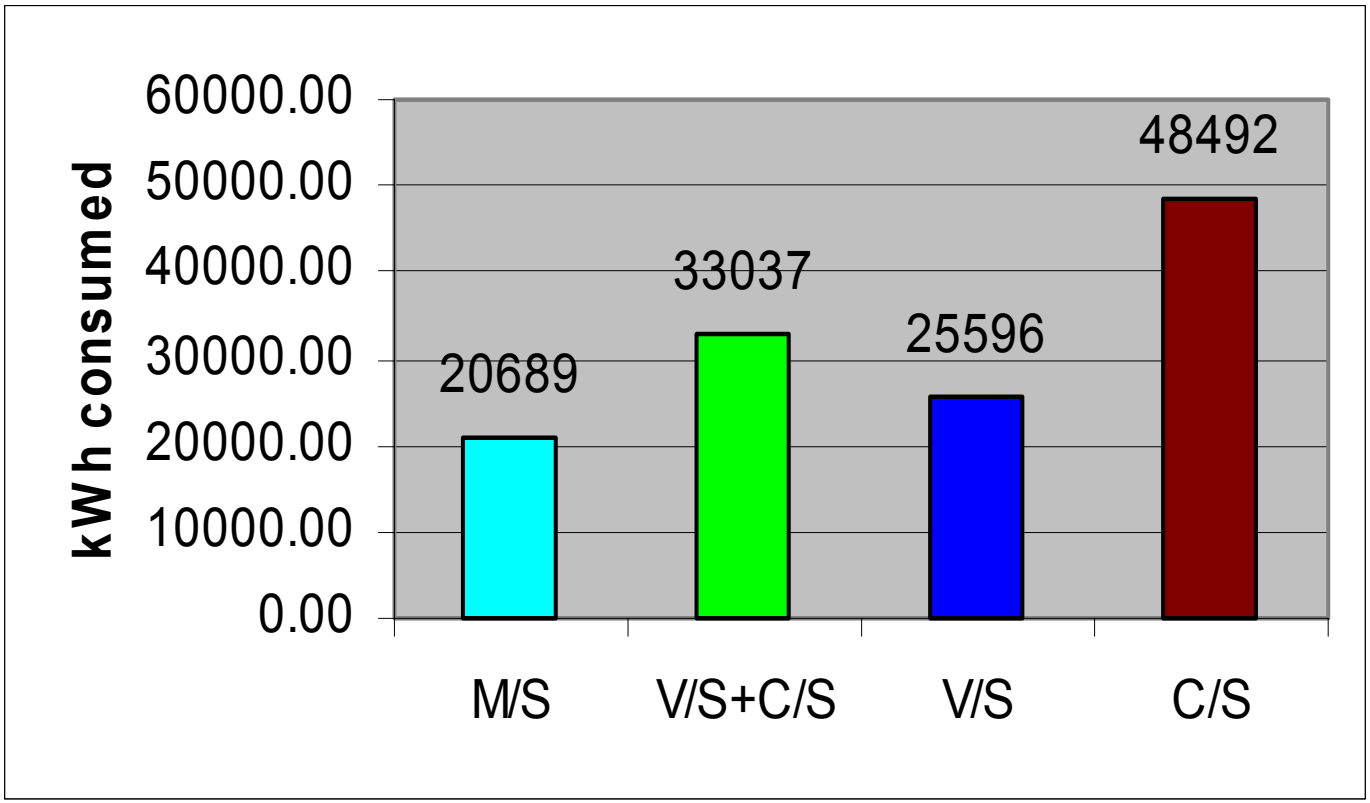


1 Best Efficiency 2 Standard Master/Slave

Global HVAC

Danfoss Taiwan

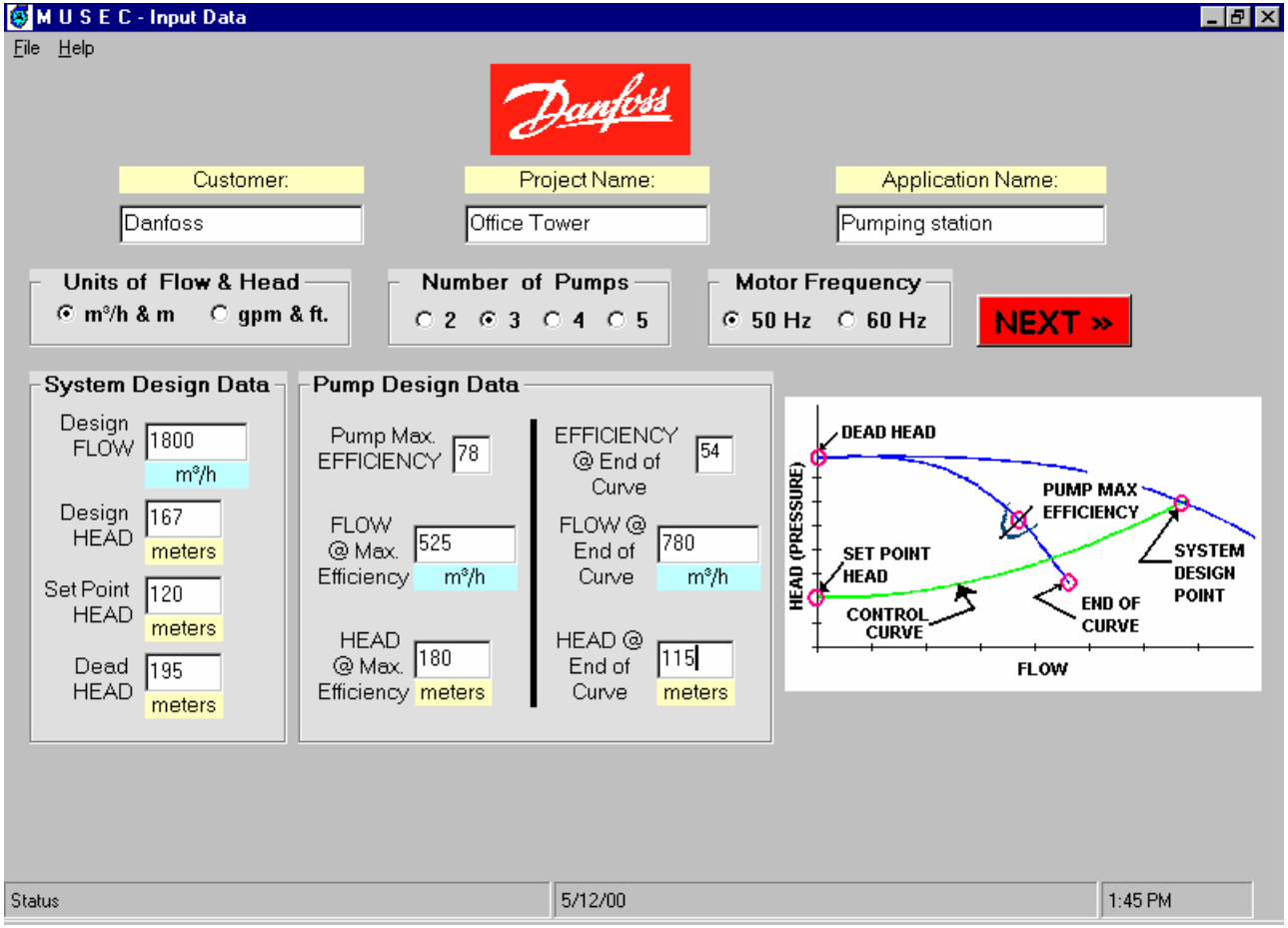
Control Options



Global HVAC

Danfoss Taiwan

Best Efficiency PC Tool

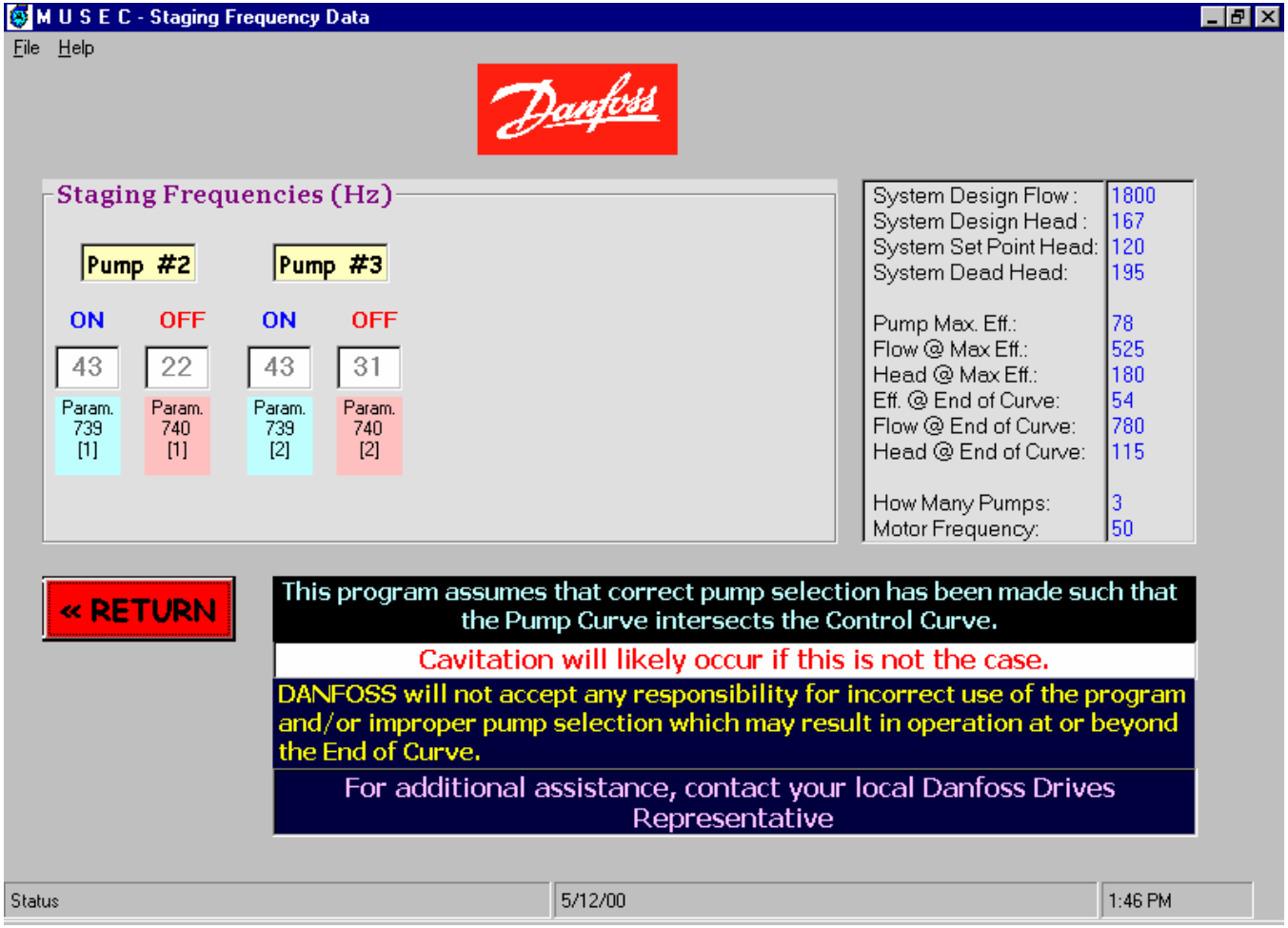


Input scheme with pump and system data

VLT The Real Drive

Danfoss Taiwan

Best Efficiency PC Tool



Output scheme with staging and de-staging frequencies

Procedure

- Input pump and system data
- The PC Tool
  - Models the pump system
  - Executes efficiency algorithms
  - Determines best stage on/off frequencies
- Program the frequencies in Parameter 739 and 740

Global HVAC

Danfoss Taiwan

New Construction

- Promote differentiating features.
  - We can easily be out-specified by competitors
  - We provide a capable system that gets the job done at a low price.
- Usually requires commissioning assistance
  - Price the option to include expected support requirements.
  - Option plus commissioning quoted together.

Global HVAC

Danfoss Taiwan

OEM Customers:

- A key market opportunity for this product
- We will make our profit selling them our drive
  - We shouldn't price the option too high or we lose our advantage
- "price protection" will be perceived
  - They will usually commission projects
  - We will be including this cost on new construction

Global HVAC

Danfoss Taiwan

Retrofit:

- The Cascade Controller is one of the important tools
- We should be selling the system based on the total payback, not based on equipment costs.
- This option will help us approach the pumping applications without the need for a BMS partner

Global HVAC

Danfoss Taiwan

FAB

Feature	Advantage	Benefit
Controller option	1 computer, not 2	1 product
5 pump controller	Very capable system	Flexibility
Combined M/S & Cascade	1 common product	1 system to be familiar with
Control curve approximation	Less over – pressurization	Better energy savings
Best Efficiency Control	Pumps operate at η max	Best energy savings

Global HVAC

Danfoss Taiwan

FAB

Feature	Advantage	Benefit
Transition Frequency	Less water hammer	Lower system damage/wear
De-stage timer	best number of pumps running	Energy savings Low wear
Operation Hour counter	Direct readout of running hrs.	Maintenance scheduling
Operation with drive trip (cc)	Redundancy	Maintain control
Pump cycling	Equal pump operating time	Averages wear