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Supersedes	**/**

Pump Control
D-EOMOC03404-25_00EN

Variable Flow

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1. VARIABLE FLOW

This document describes all features of Variable Flow option for single chiller applications with **Primary or Primary +Backup pumps**. For multi-chiller application please contact factory.

Three different control modes can be enabled by unit configuration menu:

1. **Fixed Speed**
2. **Variable Primary Flow (VPF)**
3. **Delta-Temperature Control (DT)**

HMI Path : Main Menu → Commission Unit → Configure Unit → Options

Setpoint/Sub Menu	Default	Default Range	Description
Pump Cntrl	On-Off	On-Off, Fixed Speed, VPF, DT	On-Off -> Classic On-Off pump management Fixed Speed -> Fixed Speed VPF -> Variable Primary Flow DT -> Evaporator Delta Temperature Control
Load PD Sns	None	0-10V 4-20mA BMS	Load Pressure Drop Sensor Type None 0-10V = Load PD sensor is connected directly to the controller and it provides a 0-10V signal 4-20mA= Load PD sensor is connected directly to the controller and it provides a 4-20mA signal BMS = Controller gets the Load Pressure Drop measure by BMS **Note!** This parameter can be set only if parameter Pump Ctrl is set to VPF, otherwise it will be automatically set as None.

2 FIXED SPEED

First control mode, **Fixed Speed**, allows an automatic pump speed variation, between three different speed settings:

- **Speed 1**
- **Speed 2**
- **Thermostat Off Speed**

Unit controller switches the pump frequency on the basis of:

1. Actual unit capacity
2. Double Speed digital input state

Referring to the flow chart, if there are no active compressors (Unit Capacity = 0%) pump speed is set to ***Thermostat Off Speed***, otherwise ***Speed 1*** or ***Speed 2*** is selected depending on the ***Double Speed*** input state. ***Speed 1*** and ***Speed 2*** have to be set in order to ensure the evaporator water flow within the admissible range of the specific chiller. All parameters can be modified through ***Variable Flow*** menu.

HMI Path : Main Menu → View/Set Unit → Pumps

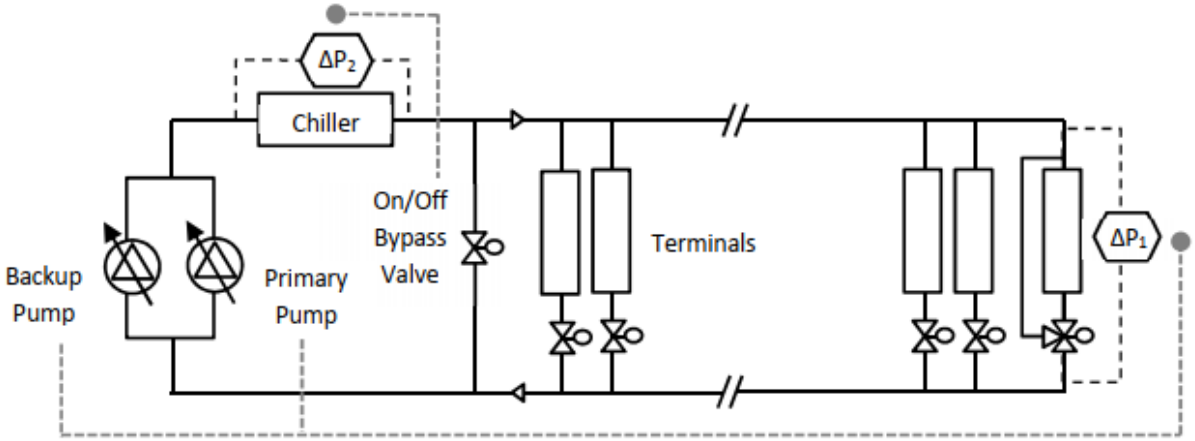
Setpoint/Sub-Menu	Default	Range	Description
Speed 1=	100%	Thermo Off Speed - 100%	Speed when the Double Speed Switch is open
Speed 2=	100%	Thermo Off Speed - 100%	Speed when the Double Speed Switch is close
Thermo Off Speed=	50%	30-100%	Speed when there are no compressors running

3 VARIABLE PRIMARY FLOW (VPF)

In the VPF systems, the pump speed is controlled to maintain a minimum pressure drop in a remote location of the plant, at a setpoint value determined to ensure the required chilled flow through any terminals or coils. Generally, this location is identified as the furthest terminal with respect to the chiller pump and it will be indicated in the following as ***Load Pressure Drop.***

Before enabling this control mode verify if the system comply with main VPF characteristics:

1. Primary only chilled water system.
2. Distribution pumps fitted with variable speed drives.
3. Terminals or coils are regulated with 2 way valve, except for one regulated with a 3 way valve in order to allow water flow if all terminals are off.
4. Bypass pipe with on/off 2 way valve must be installed near to the pumps in order to ensure a minimum evaporator water flow.



3.1 Pump Speed Control

When the system is enabled, unit controller reads the Load Pressure Drop measure ΔP1 and provides a 0-10V signal as reference for variable speed drive. Control signal is generated by a PI algorithm, and it is always limited between a minimum and maximum value set by default to 0% and 100%.

During plant maintenance operations which could compromise the sensor reading, users can also decide to temporary disable the feedback control and enable a manual mode with fix speed to avoid abnormal behavior of the system. Manual Mode and Manual Speed can be set by controller HMI.

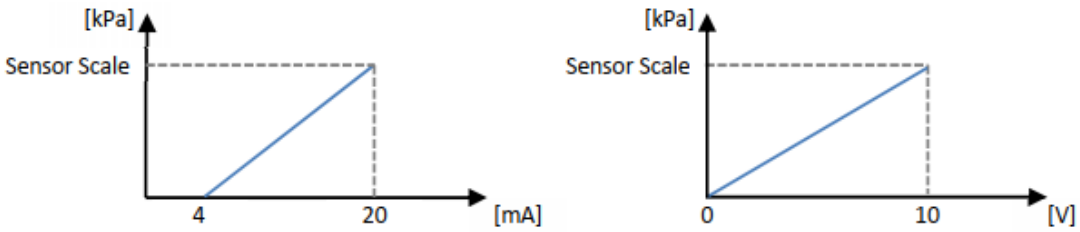
3.2 Bypass Control

When there is a low demand for chilled water by coils, the system flow rate may be lower than the minimum flow rate required by the chillers. Unit controller always compares the evaporator pressure drop measure ΔP2 with the minimum allowed value and controls the bypass valve state to maintain minimum chiller flow.

Evaporator Pressure Drop < Minimum Evaporator Pressure Drop Setpoint → Valve Opened
Evaporator Pressure Drop > Minimum Evaporator Pressure Drop Setpoint + Hysteresis → Valve Closed

3.3 Sensors

ΔP1 - *Load Pressure Drop* transducer can be provided by factory or installed on site. Unit controller receives both 4-20mA or 0-10V signals and evaluates the pressure value with linear characteristics. Sensor scale value is a parameter changeable by controller HMI.



In some applications controller and sensor could be separated by a high distance to make impossible a wired connection. For this reason, unit controllers can be set to get this measure via Modbus or BACNet communication. Note that a low refresh rate can introduce under-over shooting of pump control. In the following table are reported register's addresses for both communication protocol:

Protocol	Register/Object Type	Address	Access Level
Modbus	Holding Register	1905	R/W
BACNet	Analog Value	115	R/W

Load Pressure Drop sensor type needs to be configured through unit configuration menu and a controller reset is required to make the setting effective.

HMI Path : Main Menu → Commission Unit → Configuration → Options

ΔP2 -*Evaporator Pressure Drop* transducer is factory provided, and it is directly installed on unit.

During alarm state of at least one of the two sensors ΔP1 or ΔP2, unit controller carries out these actions until normal sensor operation is restored:

- Pump speed fixed to the Maximum value.
- Bypass valve opened.
- Warnings displayed on the controller alarm page: **"*EvapPDSen*" - "*LoadPDSen*"**

3.4 VPF setup menu

Table below reports all parameters available in Variable Flow menu when Variable Primary Flow mode is enabled.

HMI Path : Main Menu → View/Set Unit → Pumps

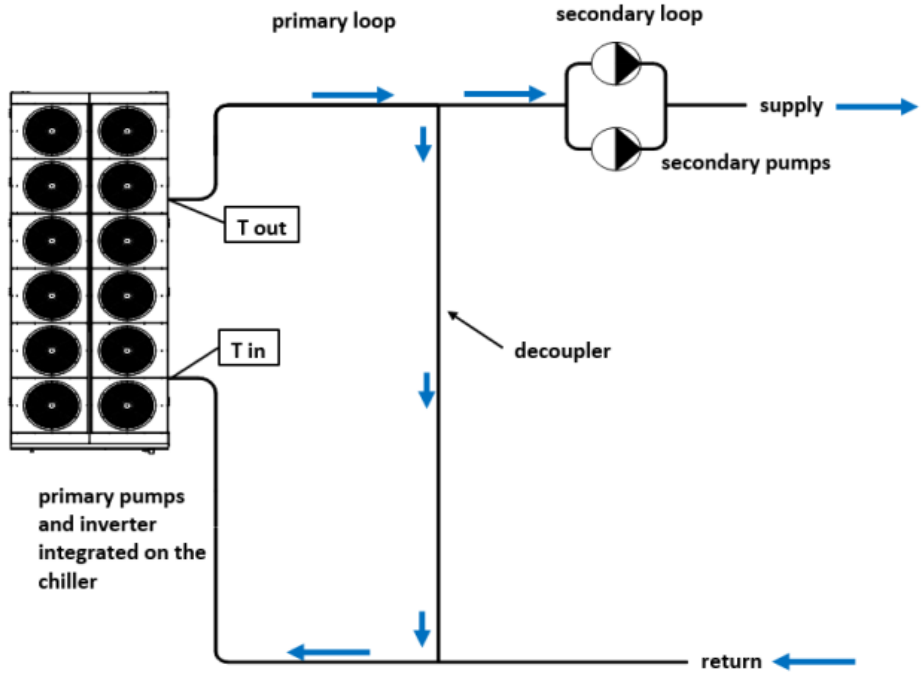
Setpoint/Sub Menu	Default	Range	Description
Plant PD=	-	-	Plant Pressure Drop. This value displays the actual pressure across the furthest terminal ΔP1.
Plant PD Sp=	0kPa	0-1000kPa	Plant Pressure Drop set point. This value defines the set point used to regulate the pump speed.
Evap PD=	-	-	Evaporator Pressure Drop. This value displays the actual pressure drop across the evaporator ΔP2.
Min Evap PD=	0kPa	0-1000kPa	Evaporator Pressure Drop set point. This value defines the set point used to regulate the bypass valve.
Pump Speed=	-	0-100%	Actual Pump Speed. This value displays the actual pump speed percentage
Min Speed=	0%	0-100%	Minimum Pump Speed. This parameter defines the minimum speed value when the pump is on.
Max Speed=	100%	0-100%	Minimum Pump Speed. This parameter defines the maximum speed value when the pump is on.
Backup Speed		0-100%	Pump Speed when a sensor fault occurs or a “No Comm Alm” between Master and Slave occur.
Mode=	Auto	Auto-Manual	Pump mode. This parameter allows you to switch the control of the pump to a fixed speed.
Manual Speed=	0%	0-100%	Manual Pump Speed. Pump speed when the manual mode is selected.
Sns Scale=	200kPa	0-2000kPa	Sensor Scale. Maximum differential pressure read by the Load Pressure Drop sensor.
Bypass=	Close	Close-Open	Bypass Valve State

4 DT PUMP CONTROL

Providing the unit with the inverter kit for the on-board pump it is possible to manage a variable water flow rate for the primary loop. This function is available as standard when the hydronic kit plus inverter is selected.
The standard feature is applicable for single unit installation only. In case of multiple chillers installation an additional control is needed.The variable flow control is suitable for primary/secondary plant, cannot be used in primary plant only.

In a Primary-Secondary plant configuration a key component is the decoupler. The decoupler is always open (no valve must be installed). The aim of the decoupler is to allow the primary and secondary pumps to operate at different flow rates. This is necessary because the primary and secondary pumps are managed differently and so the primary and secondary flow rate are practically never the same. Specifically, the primary flow rate is managed based on the chiller delta-T (Tout - Tin), the secondary flow rate is regulated to maintain the necessary pressure differential in the secondary loop. The direction of the water flows through the decoupler must be always from supply to return.

By activating the variable flow control in DT, the chiller will modulate the water flow rate based on the chiller delta. When the secondary loop will reduce the water flow rate (because the plant load decreases), the water flow rate in the decoupler (always from supply to return) increases. The return water temperature mixes with the supply water from the decoupler, reducing the water temperature, the inlet temperature and so the delta-T on the chiller. As consequence the chiller control reduces the speed of the pump, reducing the primary flow rate. On the opposite, when the flow rate on secondary flow increases also the water temperature at the chiller inlet increases (increasing the delta-T); therefore, the chiller control will increase the water flow rate.



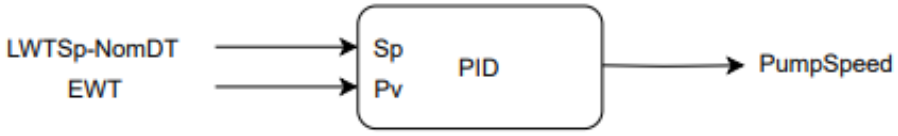
4.1 The Control Logic

The Logic for DT pump speed control is related mainly on two variables:

- **The Evap Nominal DTmp;**
- **The Entering Water Temp.**

The pump is controlled though a PID based on the EWTmp, with a Setpoint defined by the following formula:

Cooling Mode : LWTmpSp + NomEvapDT;
Heating Mode : LWTmpSp – NomEvapDT.

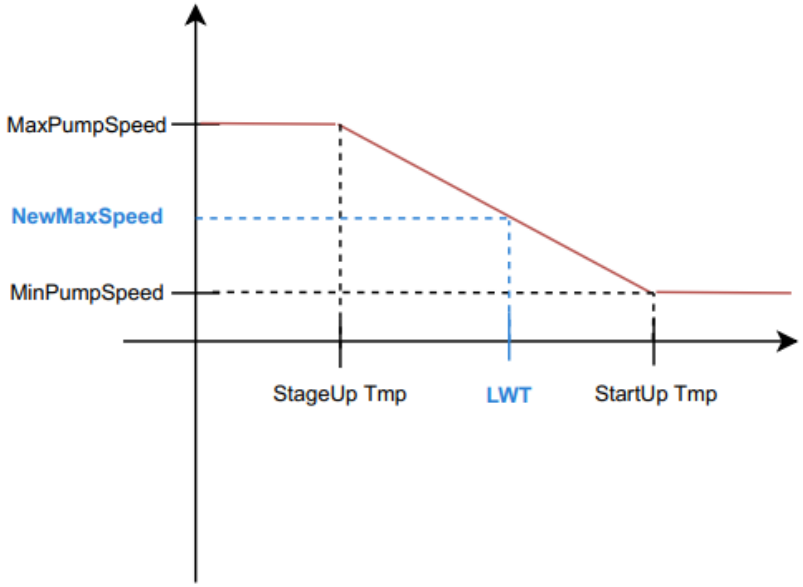


Heat Pump Control Case

So, the desired setpoint of the Leaving WTmp and the Nominal Delta Tmp of the evaporator, generate a setpoint of the pump speed control, that will regulate on the Entering Wtmp.

This will guarantee a shorter time to reach the water outlet setpoint, and better control after the transients.

When the unit is switched on, the control in DT will initially prefer to reach the water outlet setpoint, and to do this it leads the PID to generate an output with a reduced speed, to decrease the flow rate and reach the desired temperature of the LWT in less time. This reduced speed is calculated as:



This means that, as the water moves closer to the setpoint, the maximum speed is reset to the setting value, and the pump starts to regulate the speed with a larger control band.
This function of starting at lower speed can be set through the variable "***Start At Low Speed***" in HMI, in the pump dedicated menu, as described in the next paragraph.

4.2 DT Setup Menu

Table below reports all parameters available in Variable Flow menu when DT Flow mode is enabled.

HMI Path : Main Menu → View/Set Unit → Pumps

Setpoint/Sub Menu	Default	Range	Description
Pump Speed	-	0-100%	Actual Pump Speed. This value displays the actual pump speed percentage
Evap DTmp	5.8	3.3-8.9	Evaporator nominal delta temperature between EWT and LWT
Min Speed	0%	0-100%	Minimum Pump Speed. This parameter defines the minimum speed value when the pump is on.
Max Speed	100%	0-100%	Minimum Pump Speed. This parameter defines the maximum speed value when the pump is on.
Thermo Off Speed	0%	0-100%	Pump Speed in Thermostat Off Unit condition
Start At Low Speed	Yes	No*Yes	Settings that allowed the pump to start with a lower initial speed
Mode	Auto	Auto-Manual	Pump mode. This parameter allows to switch the control of the pump to a fixed speed.
Manual Speed	0%	0-100%	Manual Pump Speed. Pump speed when the manual mode is selected.

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