

BAC Refrigeration Controls

Sequence of Operation



**BALTIMORE
AIRCOIL COMPANY**

NOTE: For the complete BAC Refrigeration Controls user manual visit www.baltimoreaircoil.com/refrigcontrolsusermanual.

Table of Contents

Section 1: Safety	3
Section 2: Total Control Package Description/Sequence of Operations.....	5
2.1 Product Description.....	5
2.2 General Control Mode Overview	6
2.2.1 Total Controls Package.....	6
2.2.2 VFD Only Package	6
2.3 Sequence of Operation	7
2.4 Sequence of Operation Overview	8
2.5 Glossary	21

Section 1: Safety

Use of Warnings and Notes

There are two types of safety instructions throughout this manual:

- Notes draw attention to a particular condition or fact, or give information on a subject.
- Warnings caution you about conditions which can result in serious injury or death and/or damage to the equipment. They also tell you how to avoid the danger. The warning symbols are used as follows:



Electricity warning warns of hazards from electricity which can cause physical injury and/or damage to the equipment.



General warning warns about conditions, other than those caused by electricity, which can result in physical injury and/or damage to the equipment.



WARNING! The BAC adjustable speed AC drive should ONLY be installed by a qualified electrician.

WARNING! Even when the motor is stopped, dangerous voltage is present at the power circuit terminals U1, V1, W1 (L1, L2, L3) and U2, V2, W2 (T1, T2 T3) and, depending on the frame size, UDC+ and UDC-, or BRK+ and BRK-.



WARNING! Dangerous voltage is present when input power is connected. After disconnecting the supply, wait at least 5 minutes (to let the intermediate circuit capacitors discharge) before removing the cover.

WARNING! Even when power is switched off from the input terminals of the BAC Drive, there may be dangerous voltage (from external sources) on the terminals of the relay outputs.



WARNING! When the control terminals of two or more drives are connected in parallel, the auxiliary voltage for these control connections must be taken from a single source which can either be one of the drives or an external supply.



WARNING! Disconnect the internal EMC filter when installing the drive on an IT system (an ungrounded power system or a high-resistance-grounded [over 30 ohm] power system).



WARNING! Do not attempt to install or remove EM1, EM3, F1 or F2 screws while power is applied to the drive's input terminals.



WARNING! Do not control the motor with the disconnecting device (disconnecting means); instead, use the control panel keys or commands via the I/O board of the drive. The maximum allowed number of charging cycles of the DC capacitors (i.e. power-ups by applying power) is five in ten minutes.



WARNING! Never attempt to repair a malfunctioning BAC Drive; contact your BAC representative for repair or replacement.



WARNING! The BAC Drive will start up automatically after an input voltage interruption if the external run command is on.

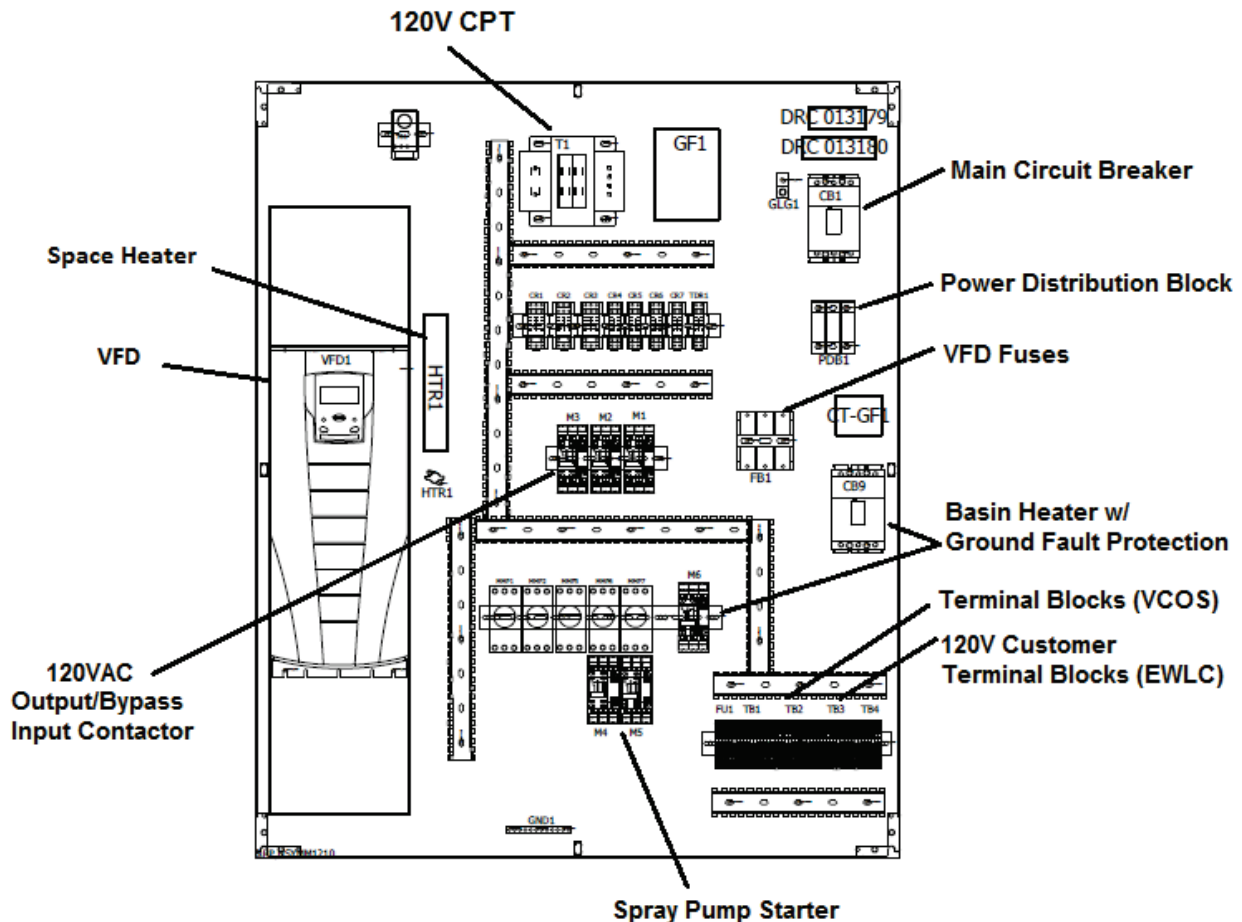
WARNING! The heat sink may reach a high temperature.

Note: For more technical information, contact the factory or your local BAC representative.

Section 2: Total Control Package Description/Sequence of Operations

2.1 Product Description

The BAC Total Control Package (TCP) provides an integrated control solution with BAC proprietary Sequencing Software to ensure efficient control of the evaporative cooling equipment. The TCP contains a VFD with fan motor control, up to two spray pump starters, up to two basin heater connections, along with an optional mechanical VCOS and EWLC connections. This configuration comes standard in a Type 3R enclosure. Control in both Hand or Auto is achievable through operator friendly controls located on the front of the door. The new TCP will help minimize installation costs and startup time.



2.2 General Control Mode Overview

The following section describes the different control modes built into the VFD logic. Control modes VFD Only, SP -> VFD, and VFD -> SP relate to the TCP offering only, while Remote Control should only be used on VFD Only applications.

2.2.1 Total Controls Package

SP -> VFD

Application: Total Control Package includes a VFD and a spray pump. Optional accessories include: Mechanical VCOS, EWLC, and/or basin heater. Auto mode will cycle on the spray pump. If the actual leaving temperature/pressure continues to rise, the VFD will cycle on to provide increased cooling. The VFD and the spray pump will remain on until the actual leaving temperature/pressure falls below the leaving setpoint. The VFD cycles off when the temperature/pressure falls below the lower deadband. The spray pump cycles off when the temperature/pressure falls below the lower limit and the Off-Delay Timer (OFDT) has expired. When the temperature/pressure begins to increase, the cycle will restart. A remote run command is required to enable the VFD.

VFD -> SP

Application: Total Control Package includes a VFD and a spray pump. Optional accessories include: Mechanical VCOS, EWLC, and/or basin heater. Auto mode will cycle on the VFD. If the actual leaving temperature/pressure continues to rise, the spray pump will cycle on to provide increased cooling. The spray pump and the VFD will remain on until the actual leaving temperature/pressure falls below the leaving setpoint. The spray pump cycles off when the temperature/pressure falls below the lower deadband and the Off-Delay Timer (OFDT) has expired. The VFD cycles off when the temperature/pressure falls below the lower limit. When the temperature begins to increase, the cycle will restart. A remote run command is required to enable the VFD.

2.2.2 VFD Only Package

VFD Only

Application: A temperature/pressure sensor provides a reference signal (4-20mA default) to the VFD. Auto Mode will modulate the fan speed to maintain the setpoint. A remote run command is required to enable the VFD.

Remote Control

Application: For VFD only applications. A temperature/pressure sensor (provided by others) or a Building Automation System would provide signals such as a speed reference to the VFD. A remote run command is required to enable the VFD.

2.3 Sequence of Operation

BAC Refrigeration Controls are designed to run in Auto or Hand Mode. In Auto Mode, the sequencing logic controls each component based on a reference signal and a setpoint. The sequencing for the logic does not apply to the remote control selection. In Hand Mode, the user can select which component will operate (all sequencing software is **disabled**).

Hand Mode

To enable Hand Mode, turn the Fan & Pump Mode selector switch to “Hand” on the panel. The Hand Enabled light will illuminate. When the Hand Enabled light is illuminated, the operator has manual control of all fans and pumps.

While in Hand Mode, the operator can select “Drive” on the Hand Mode selector switch to enable and start the VFD/fan motor. The fan motor will operate at the preset speed configured during the Start-Up Wizard.

In Hand Mode, the internal logic is disabled. To stop the VFD in Hand Mode, the operator shall select “Off” on the Hand Mode selector switch.

To enable VFD Bypass mode (Bypass the VFD to run the fan motor at 100% speed), turn the Hand Mode selector switch to “Bypass.”

To manually operate the spray pump(s) in Hand Mode, turn the Spray Pump selector switch to “ON.” (Note: the Spray Pump selector switch is disabled when the Fan & Pump Mode selector switch is in Auto Mode.)

Auto Mode

To enable the internal Sequencing Software, turn the Fan & Pump Mode selector switch to “Auto.” (All manual selector switches will now be disabled.)

To allow the spray pump to cycle automatically in Auto Mode, turn the Spray Pump Wet/Dry selector switch to “Wet.” To disable the spray pump from cycling on in Auto Mode, turn the Spray Pump Wet/Dry selector switch to “Dry.” (Note: The Wet/Dry selector switch is disabled when the Fan & Pump Mode selector switch is in Hand Mode.) Once the actual leaving temperature/pressure exceeds the set point, the Sequencing Software will be enabled and the fans and spray pump(s) will cycle when required.

For more information on the actual sequence of operation for each control mode, see control sequences in this section.

Note: The Basin Heater(s) selector switch cycles between Auto Mode or OFF. The heater will not operate in Auto Mode, nor in Hand Mode when the fan or spray pump is running.

Note: The VCOS Fault Reset pushbutton resets the VCOS fault on the TCP.

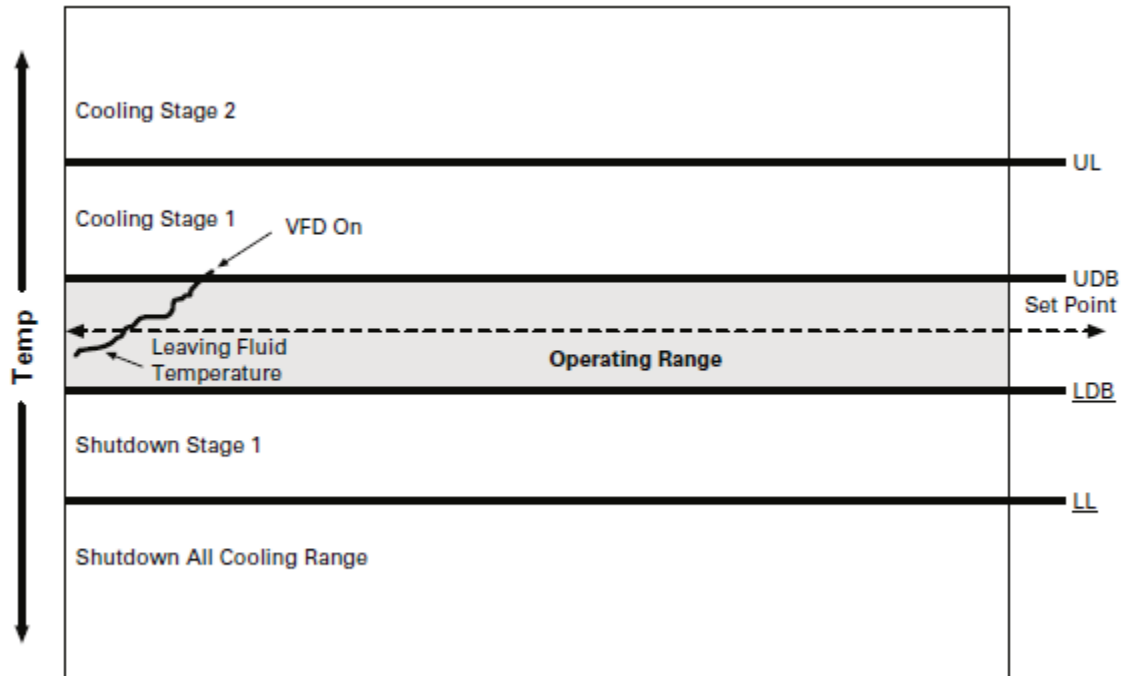
Note: The Drive Ready light will only illuminate when the VFD Drive Power switch is ON and the VFD is in a ready state. **The VFD Key Pad must be in AUTO.**

2.4 Sequence of Operation Overview

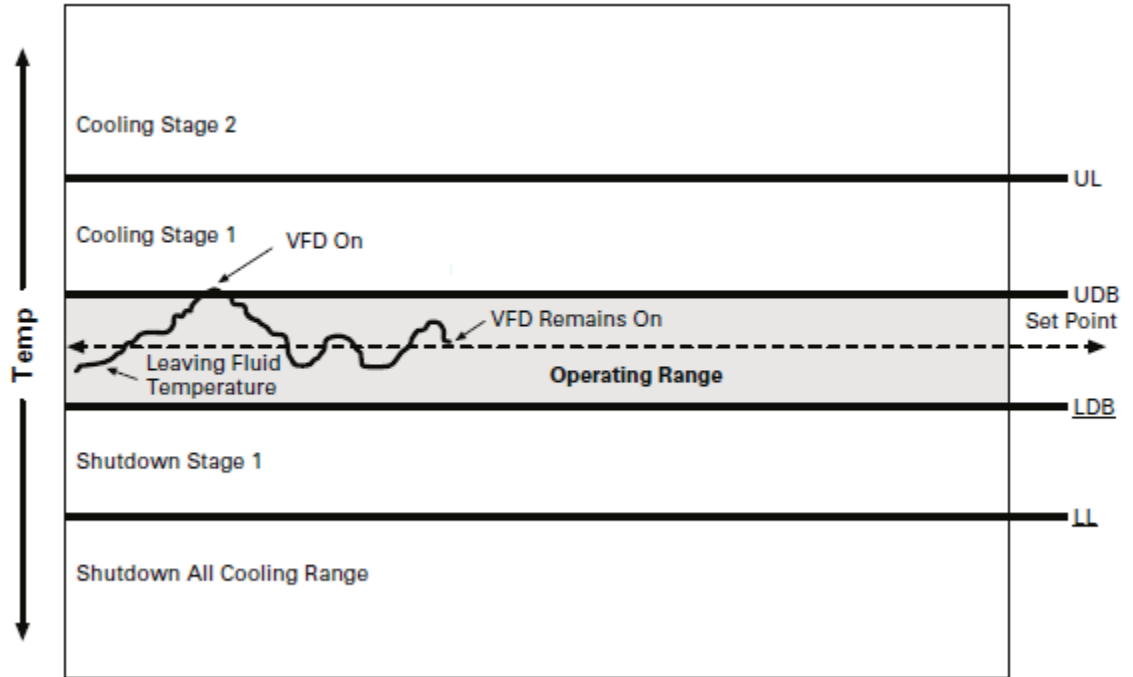
For a Glossary, see section 4.5.

VFD Only

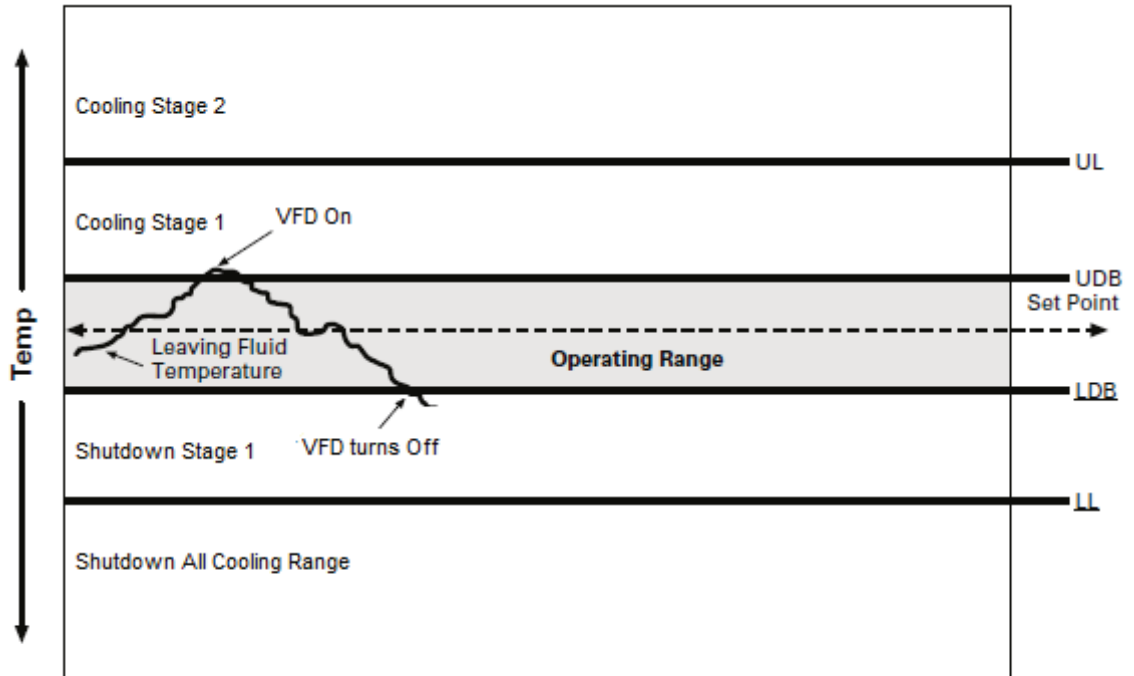
1. The control module receives a remote start signal.
 - a. The system pump is controlled by others.



2. The control module starts reading the leaving fluid temperature. If the leaving fluid Temperature/pressure is greater than or equal to the upper dead band, then it cycles the VFD motor ON.
 - a. The VFD motor will be modulated from minimum to maximum speed based on the output from a PID loop. The PID loop is initiated when the leaving fluid temperature/pressure rises above the set point and modulate the motor-speed. The job of the control module is to keep the fluid temperature at the set point within the dead band.



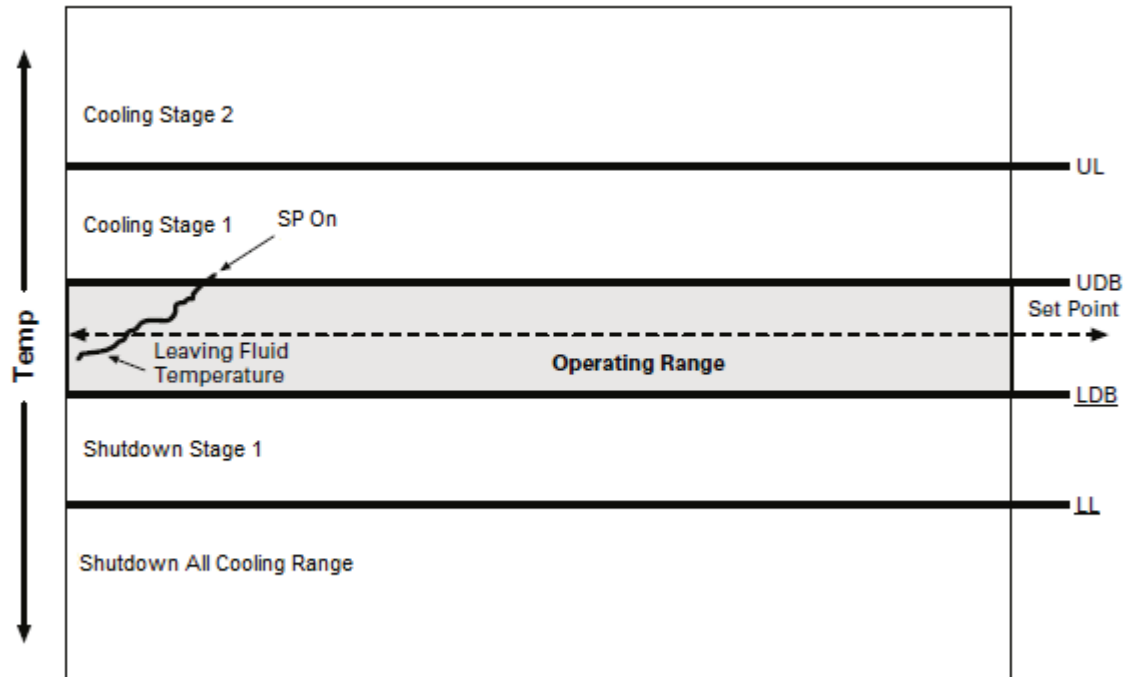
- b. VFD motor shall remain ON as long as the leaving fluid temperature is greater than the lower dead band. VFD motor shall operate at minimum speed as long as the leaving fluid temperature/pressure is less than the set point but greater than the lower dead band.



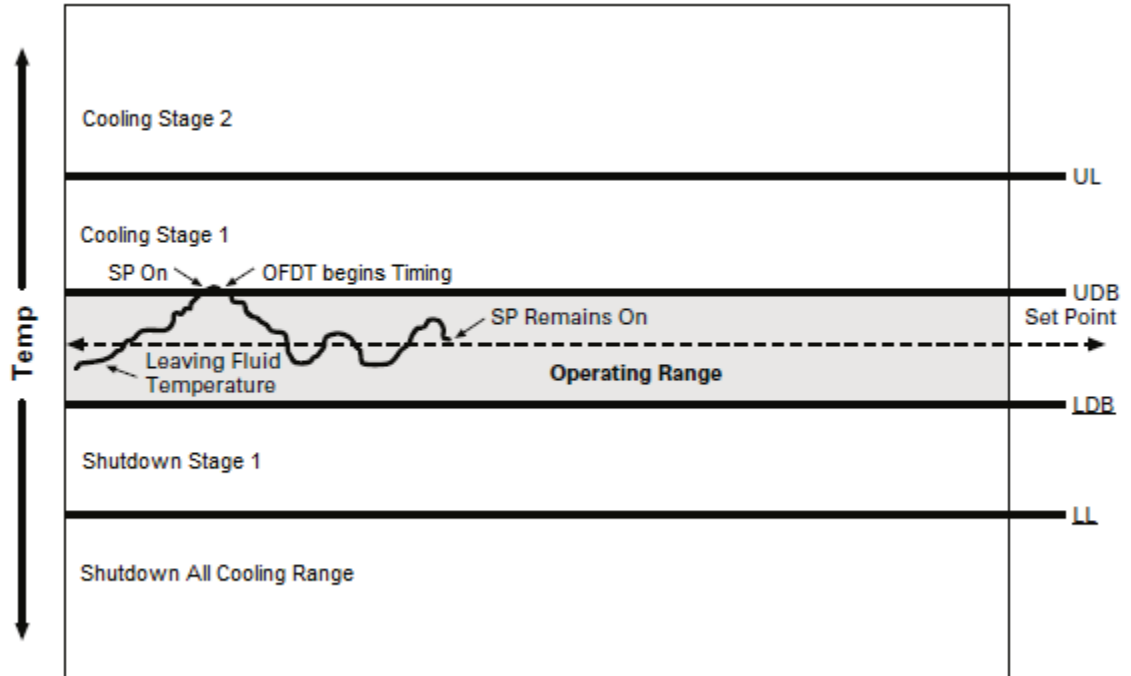
- c. VFD motor will turn OFF when the leaving fluid temperature/pressure is less than the lower dead band.
3. The control module will continue to read the leaving fluid temperature/pressure and repeat the VFD operation conditions based on this information.

Spray Pump to VFD (SP -> VFD)

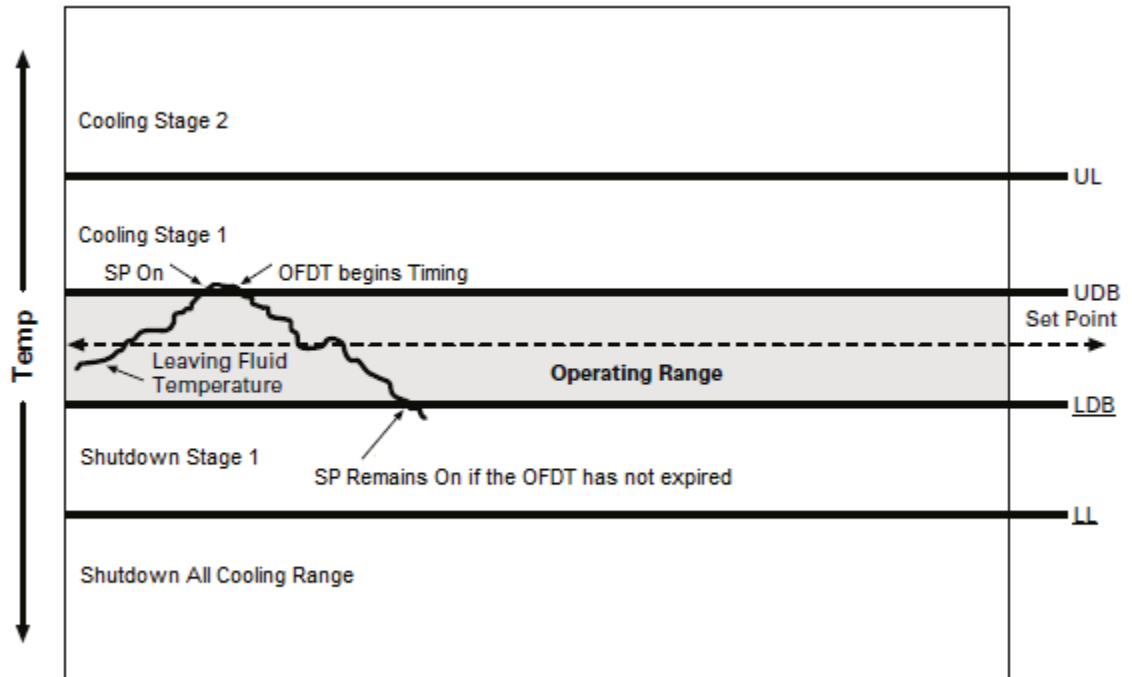
1. The control module receives a remote start signal.
 - a. The process refrigerant system is controlled by others.



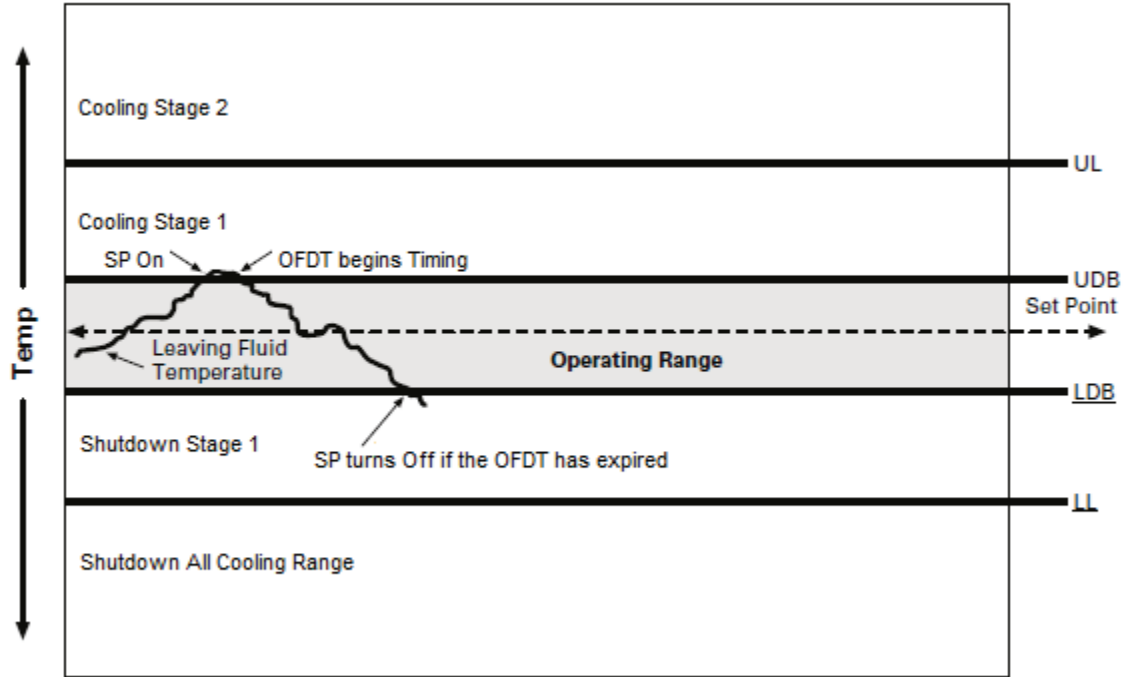
2. The control module starts reading the leaving fluid temperature/pressure. If the leaving fluid temperature/pressure is greater than the upper dead band, the spray pump will cycle ON.
3. The spray pump will be on for a minimum amount of time to prevent short cycling and also to prevent scale buildup on the coil and/or fill material from wetting and drying.



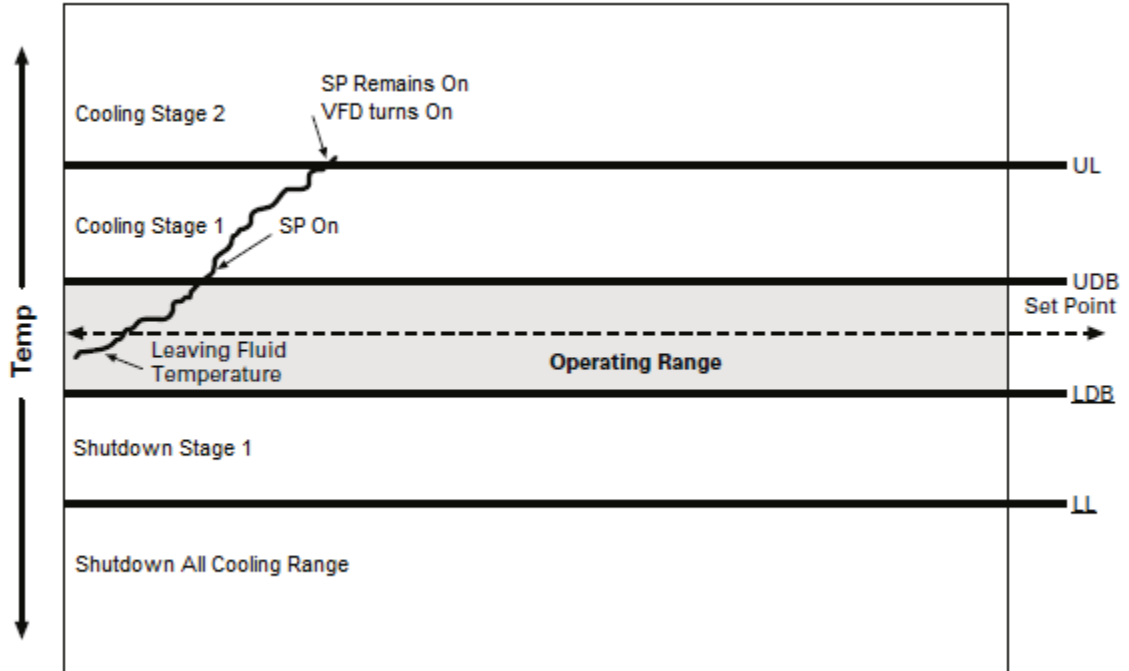
- a. Spray pump shall remain ON as long as the leaving fluid temperature/pressure is greater than the lower dead band.



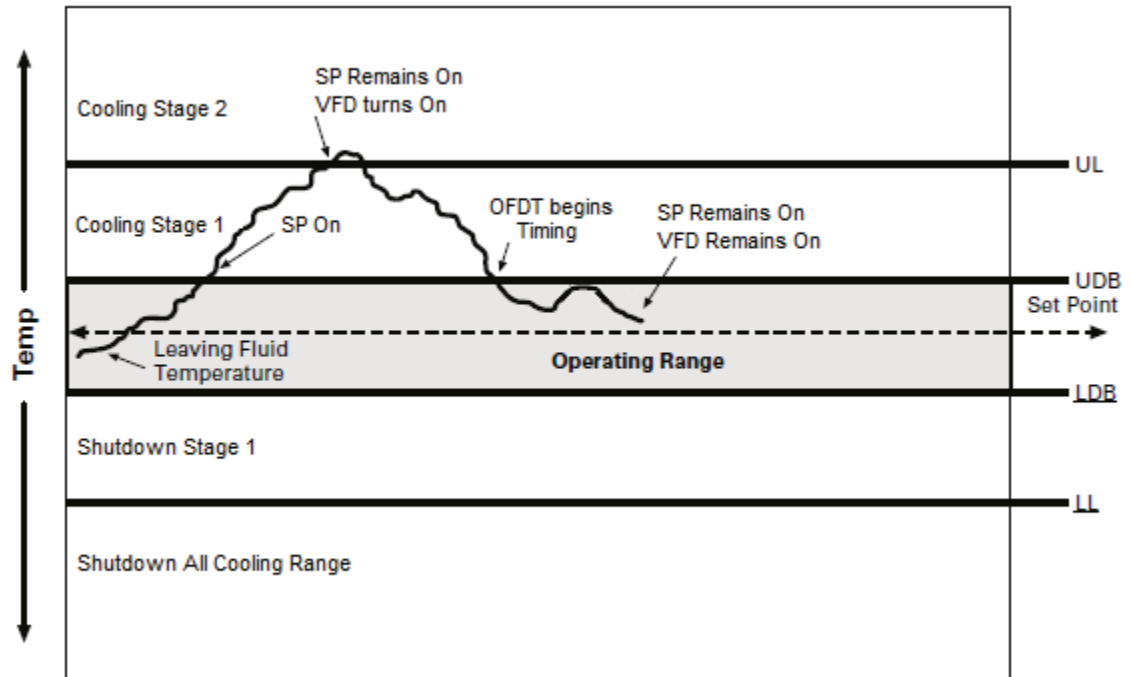
- b. Spray pump shall remain ON as long as the leaving fluid temperature/pressure is less than the lower dead band but greater than the lower limit, and the Off-Delay Timer has not expired.



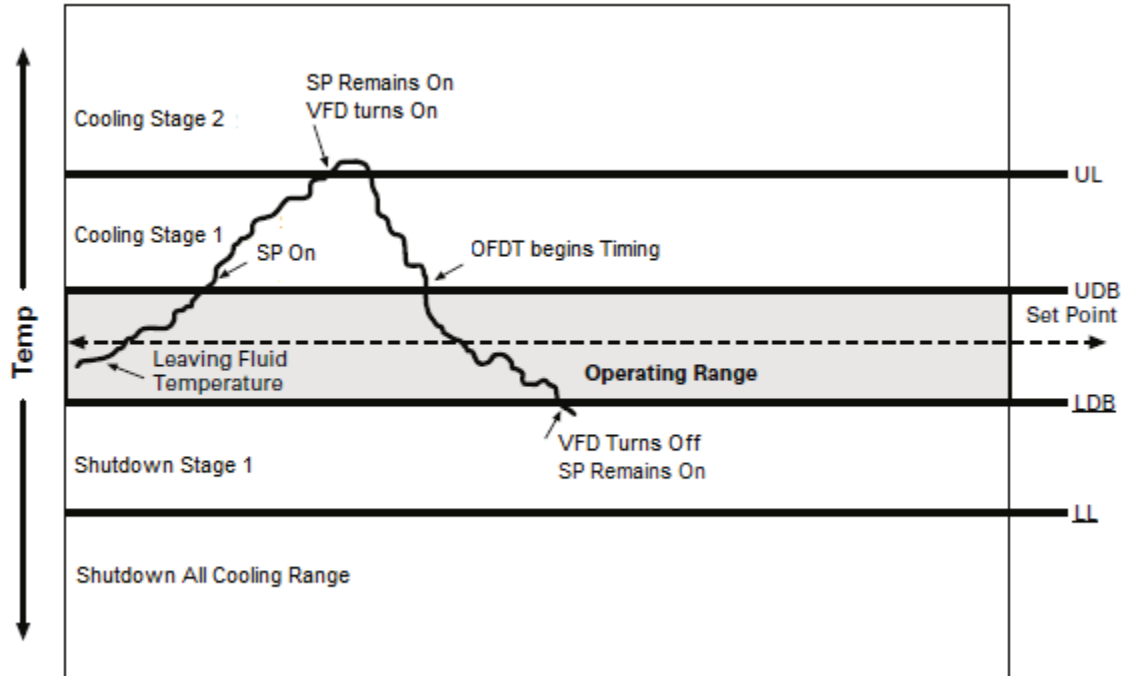
- c. Spray pump will turn OFF when the leaving fluid temperature/pressure is less than the lower dead band but greater than the lower limit, and the Off-Delay Timer has expired.



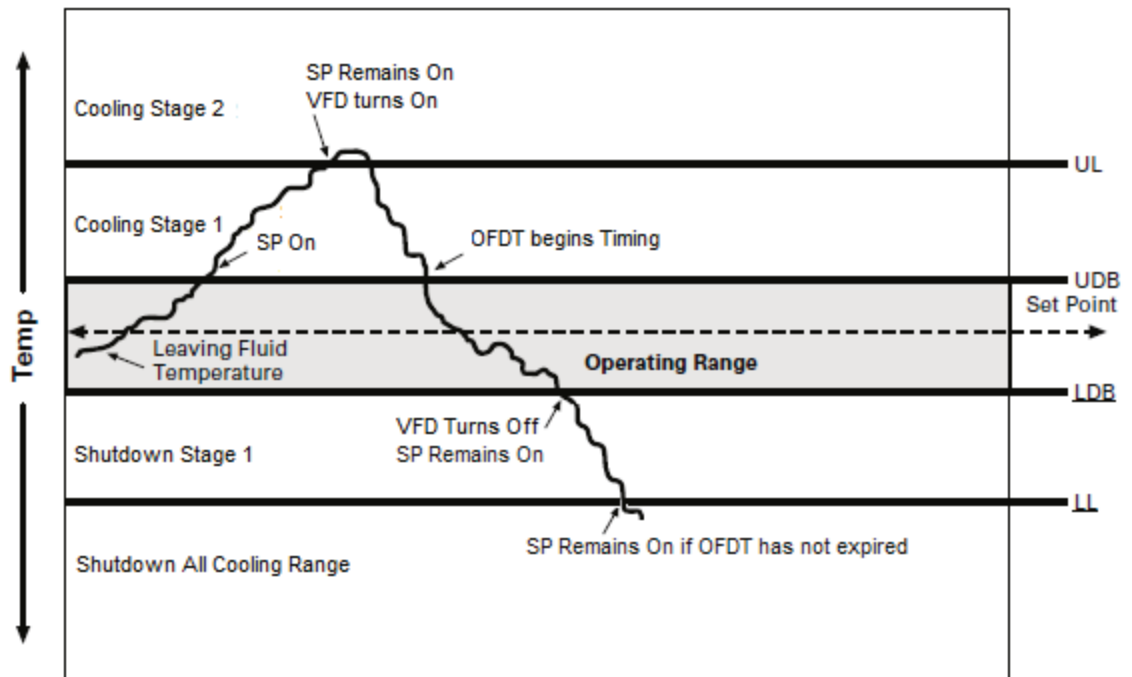
4. The control mode shall switch the VFD motor ON, to operate it with the spray pump if the leaving fluid temperature/pressure exceeds the upper limit.



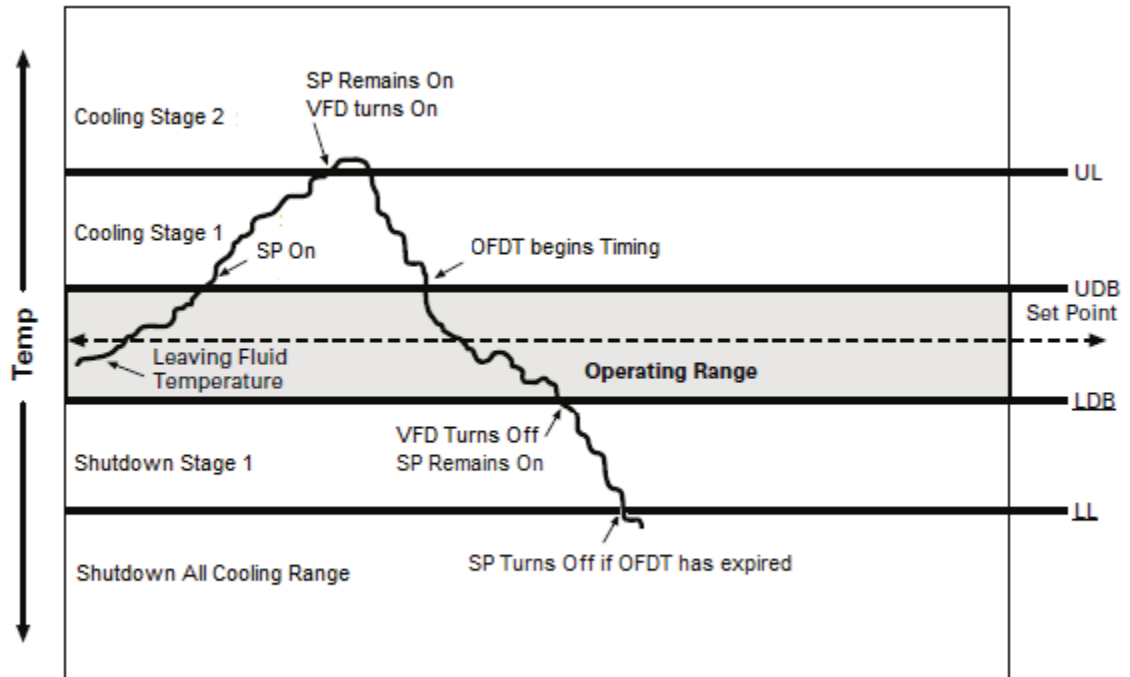
5. The VFD motor and the spray pump shall remain ON as long as the leaving fluid temperature/pressure is greater than the lower dead band regardless of the Off-Delay Timer.
- a. The VFD motor will be modulated from minimum to maximum speed based on the output from a PID loop. The PID loop would be initiated when the leaving fluid temperature/pressure rises above the set point and modulate the motor-speed. The job of the control module is to keep the fluid temperature/pressure at the set point within the dead band.



- b. VFD motor will operate at minimum speed when the leaving fluid temperature/pressure is less than the set point but greater than the lower dead band. The VFD motor will cycle OFF when the leaving fluid temperature/pressure is less than the lower dead band.
- c. The spray pump shall remain ON as long as the leaving fluid temperature/pressure is greater than the lower limit, regardless of the Off-Delay Timer value.



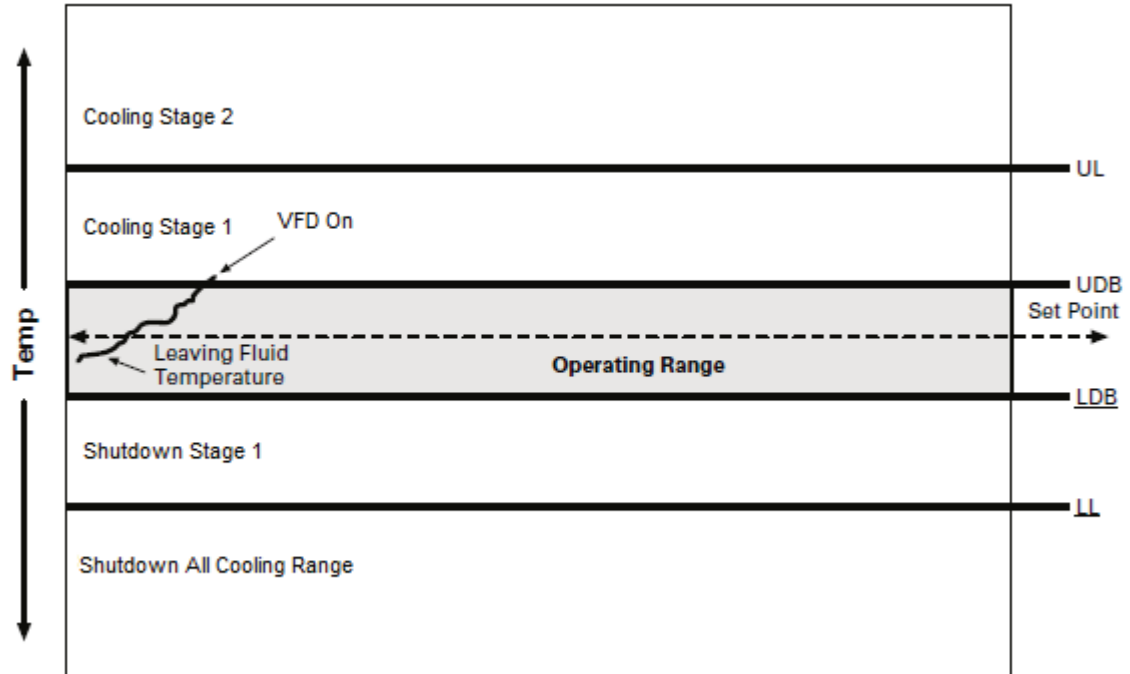
- d. The spray pump will remain On if the leaving fluid temperature/pressure is less than the lower limit and the Off-Delay Timer has not expired.



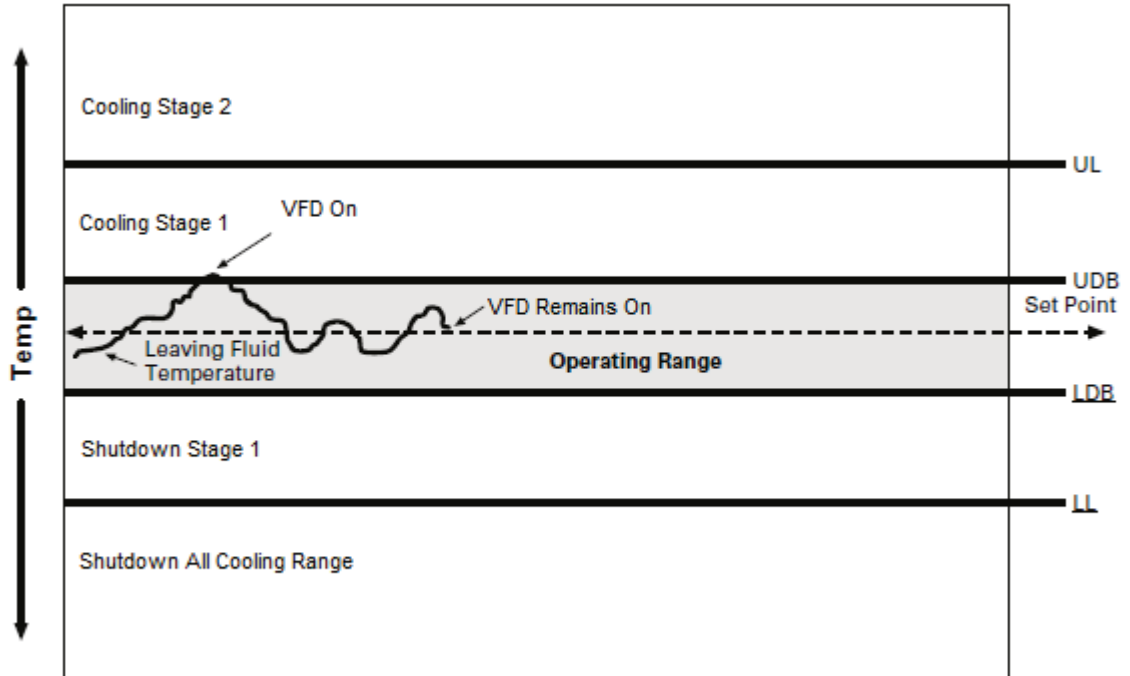
- e. The spray pump will turn Off when the leaving fluid temperature/pressure is less than the lower limit and the Off-Delay Timer has expired.
6. The control module will continue to read the leaving fluid temperature/pressure and continue to operate in SP -> VFD mode based on this information.

VFD to Spray Pump (VFD -> SP)

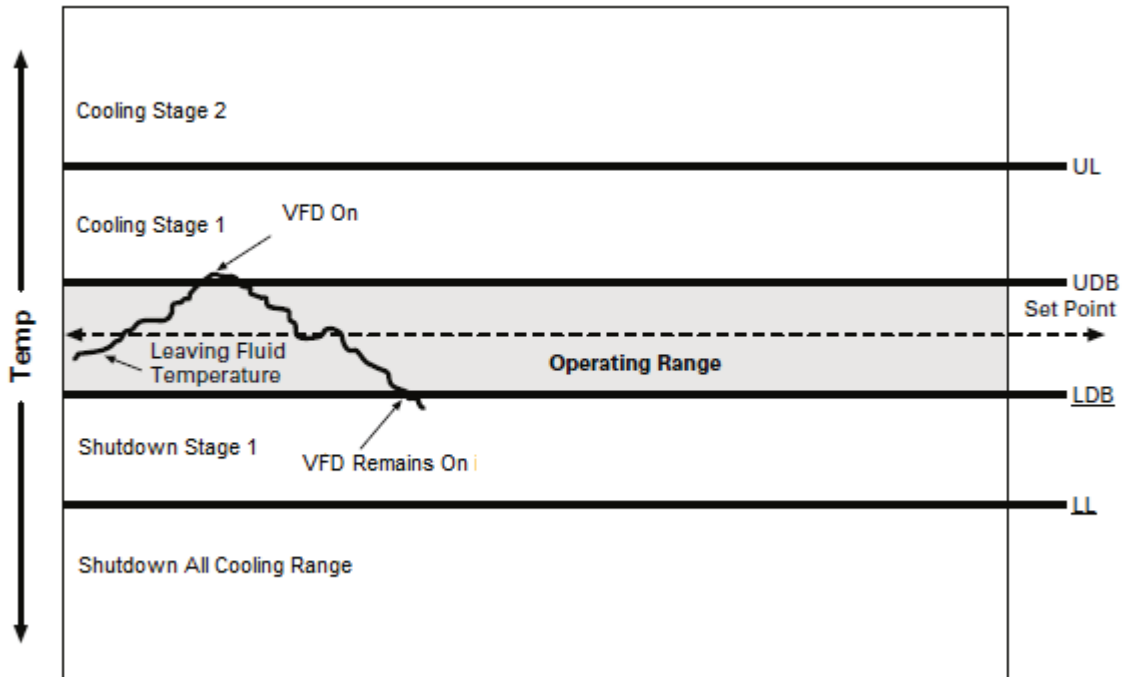
1. The control module receives a remote start signal.
 - a. The process fluid/refrigerant system is controlled by others.



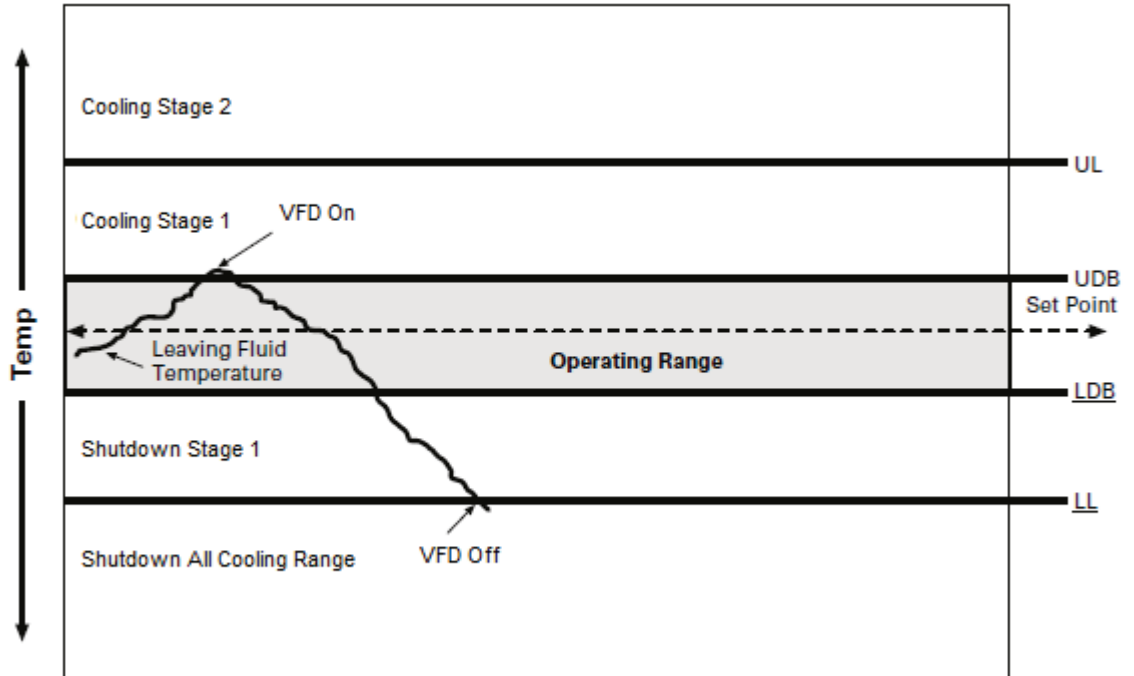
2. The control module starts reading the leaving fluid temperature/pressure. If the leaving fluid temperature/pressure is greater than the upper dead band, the VFD will cycle ON.
 - a. The motor will be modulated from minimum to maximum speed based on the output from a PID loop. The PID loop would be initiated when the leaving fluid temperature/pressure rises above the set point and modulate the motor-speed. The job of the control module is to keep the fluid temperature/pressure at the set point within the dead band.
3. The spray pump will be on for a minimum amount of time to prevent short cycling and also to prevent scale buildup on the coil and/or fill material from wetting and drying.



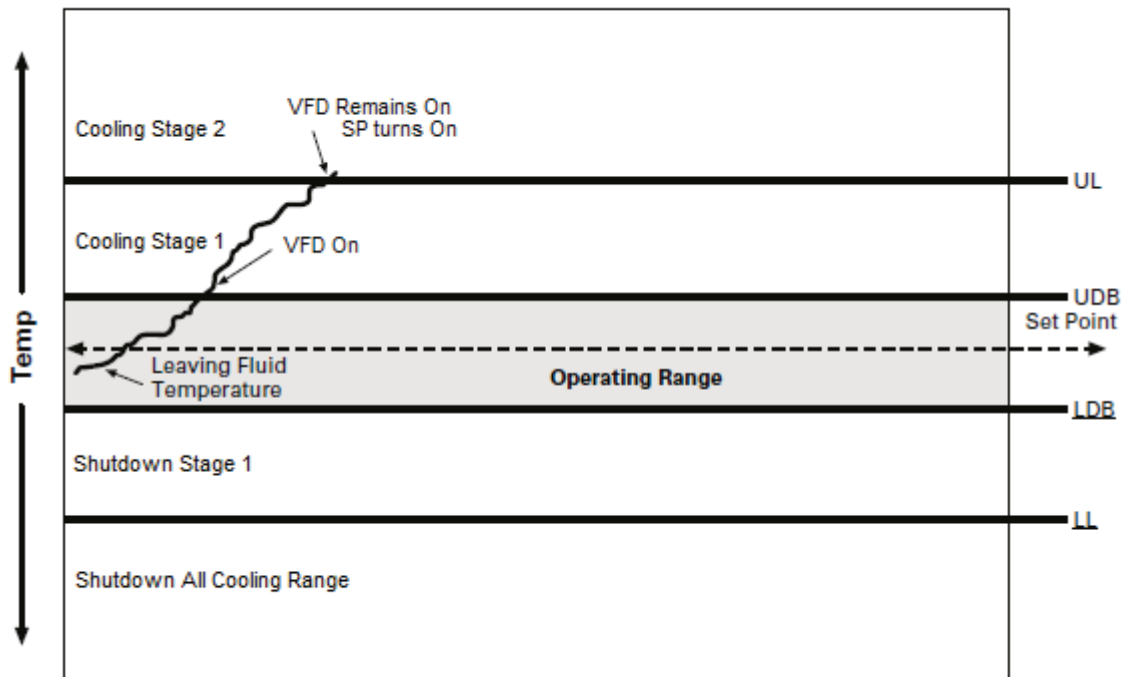
- a. VFD shall remain ON as long as the leaving fluid temperature/pressure is greater than the lower limit.



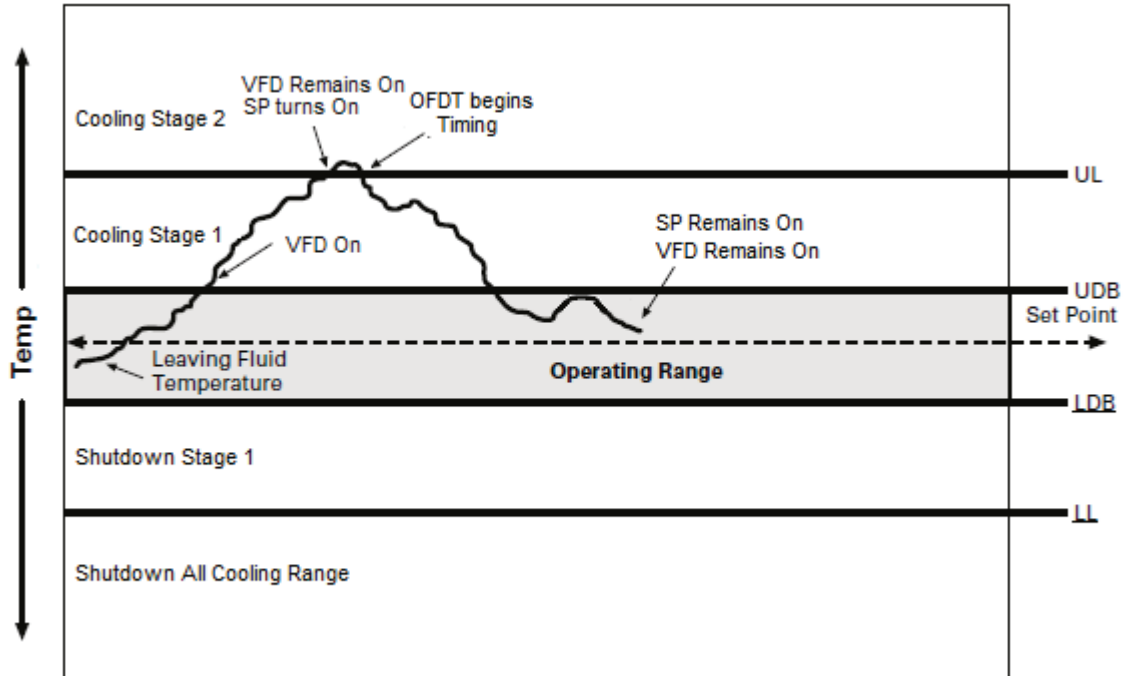
- b. VFD shall remain ON at minimum speed as long as the leaving fluid temperature/pressure is greater than the lower limit and below the setpoint.



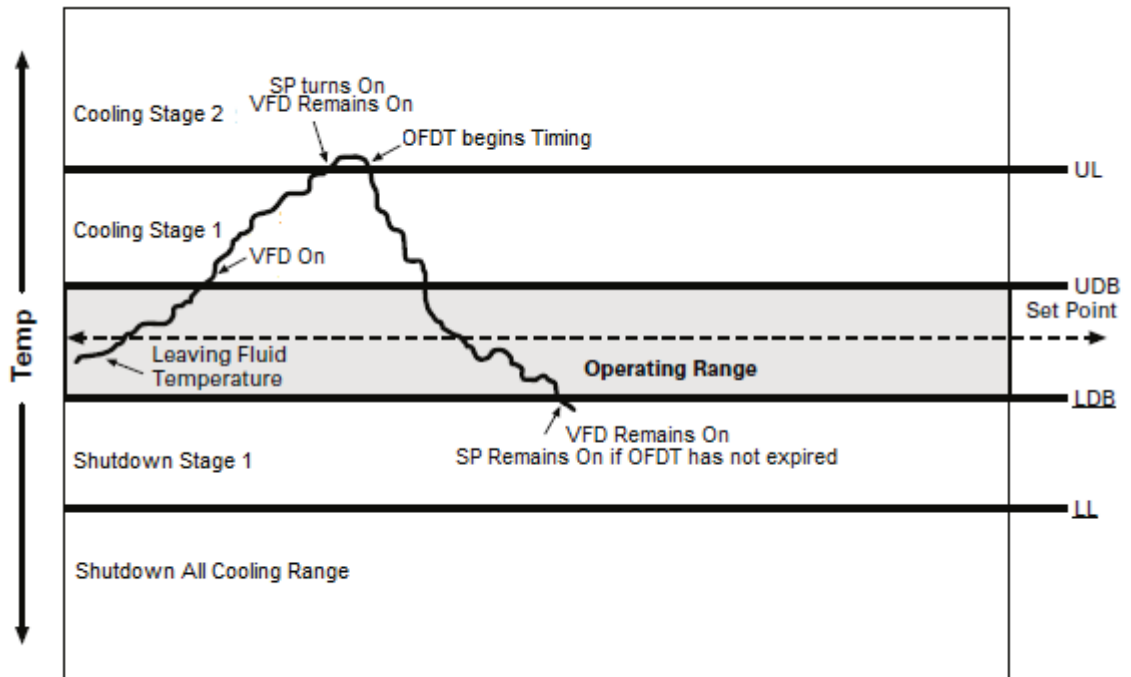
- c. VFD will turn OFF when the leaving fluid temperature/pressure is less than the lower limit.



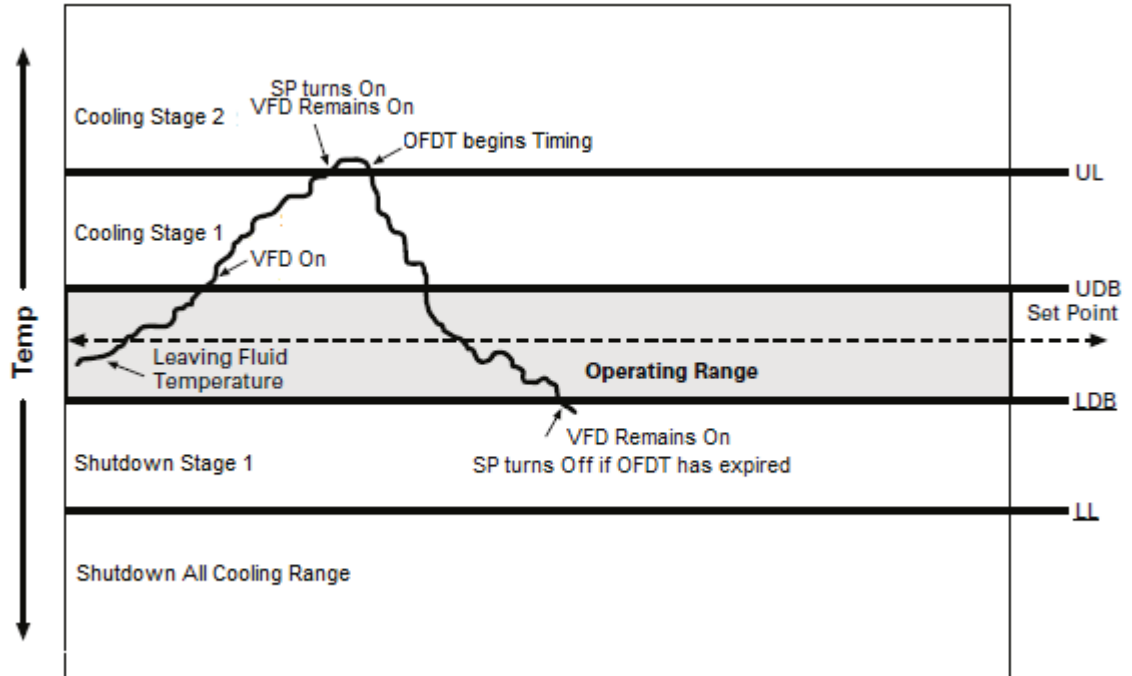
- 4. The control mode shall switch the spray pump ON, if the leaving fluid temperature/pressure exceeds the upper limit.



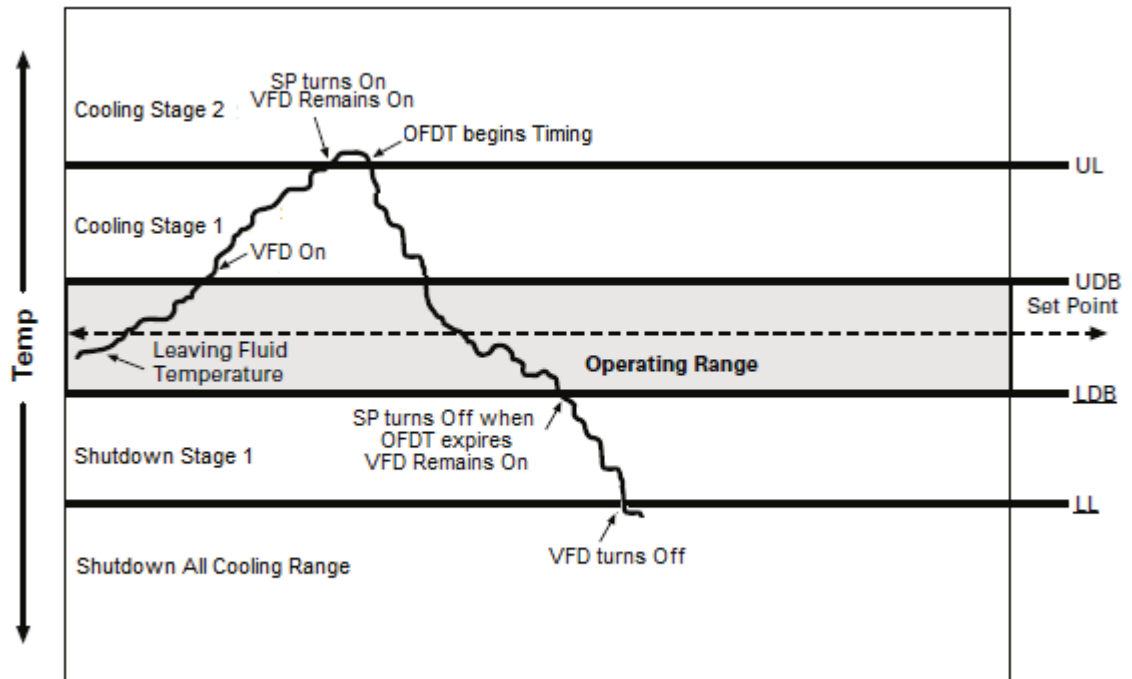
5. The VFD motor and the spray pump shall remain ON as long as the leaving fluid temperature/pressure is greater than the lower dead band.



- a. VFD motor will remain ON at minimum speed as long as the leaving fluid temperature/pressure is greater than the lower limit. The spray pump shall remain ON as long as the leaving fluid temperature/pressure is less than the lower dead band but greater than the lower limit, and the Off-Delay Timer has not expired.



- b. The spray pump will turn OFF when the leaving fluid temperature/pressure is less than the lower dead band and the Off-Delay Timer has expired.



- c. VFD motor will turn OFF when the leaving fluid temperature/pressure is less than the lower limit.
- 6. The control module will continue to read the leaving fluid temperature/pressure and continue to operate in VFD -> SP mode based on this information.

2.5 Glossary

Set Point (SP): the target value the operator enters into the controller to maintain the cooling tower leaving fluid temperature/pressure.

Leaving Fluid Temperature (LFT): measured in coil leaving fluid piping using a RTD temperature transducer providing a 4-20mA output.

Leaving Fluid Pressure (LFP): measured in coil leaving fluid piping using a pressure transducer providing a 4-20mA output.

Dead Band (DB): range in which no action occurs. The dead band range is (dead band/2) above and below the set point.

Upper Dead Band (UDB): the value for bringing on additional stages for increased capacity. Upper dead band is calculated by set point + (dead band/2).

Lower Dead Band (LDB): the value for turning off stages for decreased capacity. Lower dead band is calculated by set point – (dead band/2).

Upper Limit (UL): the value above set point that will cause the controller to turn on the next stage of capacity. The Upper Limit is calculated by set point + limit.

Lower Limit (LL): The value below set point that will cause the controller to turn off the current stage of capacity. The Lower Limit is calculated by set point – limit.

Off-Delay Timer (OFDT): The minimum amount of time the spray pump will operate before turning off.

EWLC: Electric Water Level Control

VCOS: Vibration Cutout Switch