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MAGNUM Condensing Unit Software

Sequence of Operations

MAGNUM Chiller V8 software

MCS Total Solution for all your Control Needs

Energy Efficient and RoHS Compliant

Revision/Disclaimer Page

Date	Author	Description of Changes
2015-3-30	DEW	New Cover and Revision page

The MCS Commitment is to provide practical solutions for the industries needs and to be both a leader and partner in the effective use of microprocessor controls.

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MAGNUM Condensing Unit Software Sequence of Operations

1. At power up the Magnum will not start its algorithm until Set Point 23, POWERUP DELAY, time has been satisfied.
2. At startup the MAGNUM verifies the 'NO RUN CAPACITY CONTROL STATES'. **Refer to Appendix A.**
3. If any one of the 'NO RUN CAPACITY CONTROL STATES' is not satisfied, the following sequence occurs:
    a. All compressors are not allowed to run. Any running compressor which has satisfied it's minimum run time (set point #64) will have its liquid line solenoid turned off and the compressor turned off. (Pump down will occur if enabled).
    b. The evaporator fan continues to run for 60 seconds (Set Point #108 "PUMP DELAY") after the last compressor is turned off.
4. If all of the 'NO RUN CAPACITY CONTROL STATES' are satisfied, the capacity control logic is now allowed to run to maintain the Supply Air Temperature (or optionally Return or Zone Temperature) within the control zone defined by:
    a. Set Point #1 "CTL TARGET "
    b. Set Point #2 "CTL ZONE+"
    c. Set Point #3 "CTL ZONE-"
5. The Capacity control logic will increase or decrease the compressors 'WANTED ON verses ACTUAL ON' and maintain the compressors required. **Refer to Appendix E for details.** Capacity control logic for loading & unloading the chiller is as follows:
    a. If the Supply Air Temperature is above the control zone and the Supply Air Temp. Rate Of Change (ROC) is not indicating the supply air temperature is already decreasing at a sufficient rate, the condensing unit's capacity control logic will ask for more capacity by adding to the "Steps Wanted On" parameter. Once "Step Wanted On" parameter has been increased the capacity control logic has a time delay before allowing the "Steps Wanted On" to be increased again. The time delay is dependant on how far away the temperature is from target, Set Points #25 "STEP SENSIT" and Set Point #26 "STEP DELAY"
    b. If the ROC indicates a sufficient decrease in Supply Air Temperature (ROC < Set Point #27 "MAX ROC-") the capacity control logic stops loading and holds the current capacity.
    c. If the supply air temperature is in the control zone, special logic functions to keep the condensing unit's within the control zone.
    d. If the supply air temperature is below the control zone and if the Supply Air Temp. Rate Of Change (ROC) is not indicating the supply air temperature is already increasing at a sufficient rate, the condensing unit's capacity control logic ask for less capacity by subtracting from the "Steps Wanted On" parameter. Once "Step Wanted On" parameter has been decreased the capacity control logic has a time delay before allowing the "Steps Wanted On" to be decreased again. The time delay is dependant on how far away the temperature is from target, Set Points #25 "STEP SENSIT" and Set Point #26 "STEP DELAY"
    e. If the ROC is indicating a sufficient increase in Supply Air Temperature (ROC < Set Point #27 "MAX ROC-") the capacity control logic stop unloading and holds the current capacity.
6. Once it has been determined that a compressor is wanted on the MAGNUM reviews the 'NO RUN CIRCUIT CONTROL STATES' for an available compressor. **Refer to Appendix B**. The MAGNUM software runs its compressor control logic every second starting with the lead compressor. If a compressor is allowed to run (not locked out, tripped on a safety or disabled by pump down and/or flow switches) and the MAGNUM wants the compressor to run ("Steps Turned On" is less than "Steps Wanted On") the compressor is started.

7. The condenser fan control logic runs once every second. Pumps and fans are cycled based on the compressor(s) discharge pressure and Set Point #45 to #55, depending on condenser type.
8. The Capacity State & Circuit/Compressor State can be viewed via the 'STATUS' option under the 'Menu' key on the MAGNUM keypad or using PC-Connect software on a Windows based computer.

The CURRENT STATE OF THE PACKAGE (Press 'Menu', position arrows to 'Status' Press Enter **(↵).**

The display shows the current capacity of the package and how long we have been at this level. By pressing the **PG↓** you will get additional information on each circuit.

ACTUAL DISPLAY

```
09:55      Unit     45/54
     UNIT IS UNLOADED
         025:42;33
WTD   ACT   WTD%   DLY    ROC
 0     0    40%   180    0.0
  TARGET=45.0 (ADJ +0.0)
              PG↑        PG↓
```

DESCRIPTION

```
HH:MM              COND. UNIT            SPLY/RTN
                CURRENT CONTROL STATE
                TIME IN CURRENT STATE
WANTED      ACTUAL      WANTED%     DELAY       SLOPE
#STEPS      #STEPS      ACTUAL%    NEXT CHG
DIRECTION
            TARGET SET POINT + TARGET RESET
                        PAGE UP              PAGE DN
```

The CURRENT STATE OF A CIRCUIT.

The display shows the current capacity of circuit (x) and how long we have been at this level. By pressing the **F2** you will go back to the Chiller state display OR **F3** you will get additional information on this circuit.

ACTUAL DISPLAY

```
09:56     CMP #(x)   45/54
       CMP OFF/READY
          000:00;30
SUCT    DISC     OPD   MOTOR
 66P    190P     134P     0%
 55F    177F     ----     OK
              PG↑        PG↓
```

DESCRIPTION

```
HH:MM              COMPRESSOR      SPLY/RTN TMP
                CURRENT CONTROL STATE
                TIME IN CURRENT STATE
  SUCTION     DISCHARGE    OIL DIFFERENTIAL   MOTOR
 PRESSURE     PRESSURE        PRESSURE          AMP
%
TEMPERATURE  TEMPERATURE       ----
STATUS
                        PAGE UP              PAGE DN
```

```
09:55     CMP #(x)   45/54
       CMP OFF/READY
          000:00:42
SST     SSH     SCT     DSH
 38    16.9      97    79.2
              PG↑        PG↓
```

```
HH:MM              COMPRESSOR      SPLY/RTN TMP
                CURRENT CONTROL STATE
                TIME IN CURRENT STATE
SAT.SUCT.    SUCT SHEAT     SAT.COND.    DISC SHEAT
  TEMP          TEMP           TEMP          TEMP

                        PAGE UP              PAGE DN
```

9. The safeties (Comp No Stop, Phase Loss, Emergency Stop, High Sump Water Temperature) are checked once every second. (All of the safeties are options features). Once a safety has occurred the user is required to correct the problem and reset the unit using the 'Lckout RST' from the Menu on the MAGNUM's keypad.
10. If the compressor relay output is turned on, either by computer or manual, the compressor safeties are checked once every second. The following compressor safeties are supported:
    a. Low & Unsafe Suction Pressure
    b. Low & Unsafe Differential Oil Pressure
    c. Low & High Discharge Pressure
    d. High Discharge, Oil and Motor Temperatures
    e. Low & High Motor Ampere
    f. No Compressor Proof
    g. Freeze protection for split barrels units

Appendix A

MAGNUM No Run Capacity Control States

There are a number of functions that will not allow the Condensing unit to run, as follows: (These may be viewed by pressing selecting 'Status" from the Menu key.)

1. **UNIT IN POWER UP**-
The MAGNUM V8 software utilizes Set Point #23 "Power Up Delay" (Typically 60 seconds) prior to starting the algorithm.

2. **RUN/STOP SW OFF**-
(Optional)- Hard-wired to a sensor input.

3. **NETWORK SW OFF**-
(Optional)- This is wired via a communication port from a BMS system.

4. **OFF- NO AIR FLOW**-
Air Flow switch input is not made. If the MCS controller controls the supply fans, the sequence is as follows:

   a. The Evaporator fan, as defined in Set Point #106 " Lead Fan", is turned on (Fan control is an optional feature) and if proof of flow is not indicated by the Flow sensor input turning ON within 30 seconds (Set Point #105) of starting the Evaporator Fan pump a "Fan Failure #1" alarm is generated.
   b. The backup evaporator fan (optional feature) is started. If the backup Evaporator Fan fails to establish proof of air flow a "Fan Failure #2" alarm is generated and the unit is turned off on no flow.

5. **NO RUN-I/O LOST**-
Communication to the Input and Output expansion boards is checked once every second. Visual verification of MCS-I/O communication can be made by viewing the LED next to the MCS-I/O terminal block. The LED should be blinking. If communication is lost to any board, the entire unit is shut down and locked out, generating a "LOST I/O SHUTDOWN" alarm. The user will need to correct the communication problem and then press the Lockout Reset button on the MAGNUM's keypad.

6. **UNIT IN LOCKOUT-**
This state is entered whenever a critical situation is encountered that could cause harm to the unit. Items such as freeze protect, no flow, invalid critical sensor and emergency stop will force the system into this state. Lockouts can be reset without authorization from the keypad or PC-Connect program; however if the lockout condition has not been corrected, the system will again be forced into the LOCKOUT state. In this state, all RO's except ALARM RO and the oil heater RO for screws with an oil pump are turned OFF & placed in the 'LOCKOUT' state.

7. **SCHEDULED OFF-**
This state is entered when the schedule is calling for the unit to be off.

8. **AMBIENT OFF-**
This state is entered whenever the ambient temperature falls below the Low Ambient Off SET POINT # 24 or is above the High Ambient Off SET POINT # 26. The system will remain in this state until the temperature changes + 5.0° F or 2.5°C.

Appendix B

MAGNUM No Run Circuit Control States

There are a number of functions that will not allow a circuit to run, as follows: (These may be viewed by selecting ‘Status” from the Menu key and using the page down function key to view each circuit.). Press the Page down key (Function 3) to view each circuit.

1. CMP LOCKED OUT-
This state is entered when the Capacity Control State is LOCK OUT or a safety Set Point for this circuit has indicated that a critical situation has been encountered. Set Points such as (LOW SUCTION #77) or (HI DISCH PSI #81) are examples of safety Set Points. Lockouts can be reset without authorization from the keypad or PC-Connect program; however if the lockout condition has not been corrected, the circuit will again be forced into the LOCKOUT State.

2. LOST IO LOCKED
This state is entered when the Capacity Control State is LOST IO. Lockout reset key will move the circuit to the OFF state. Lockouts can be reset without authorization from the keypad or PC-Connect program; however if the lockout condition has not been corrected, the circuit will again be forced into the LOCKOUT State.

3. SAFETY TRIPPED
This state is entered when a safety trips but a lockout is not to be generated. An alarm is generated but the system will restart after the delay specified in the corresponding Set Point. If a second trip occurs within the time specified in the Set Point, the circuit will be placed in the CMP LOCKED OUT State.

4. CMP OFF/READY
This state is entered when no cooling capacity is required from this circuit or the prior state was CMP ANTICYCE, LOST IO LOCKED or SWITCHED OFF. In this state the circuit is ready to provide cooling capacity if needed. The system will remain for a minimum delay of 60 seconds in this state.

5. CMP PMP DOWN
This state is entered whenever the pump down switch has been turned on or if this circuit is no longer wanted on. The compressor is on and the liquid line solenoid is closed. This state is active until the suction pressure reaches the value in the Set Point 61, PMP DWN OFF or the time has exceeded the value in the Set Point 62, PMP DWN DELY. The circuit will then move to the ANTICYC State.

6. CMP ANTICYCLE
This state is entered when the PMP DWN State has been completed. The circuit will stay in this state with all circuit points off for the period of time contained in Set Point 59, ACYC ON TO ON or Set Point # 63 ACYC OFF TO ON. The circuit will then move to the OFF State.

7. SWITCHED OFF
This state is entered after the circuit has been pumped down due to (1) the circuit pump down / disable switch being on, (2) the circuit flow switch is off or (3) the logic is enabled for low temp or high temp sensor. In this state the compressor and all related points, plus the liquid line, are off. The circuit will not leave this state unless the pump down switch is

turned off or the temperature is ok. If the pump down switch is turned off, the circuit-state will be changed to the OFF State.

Appendix C

MAGNUM Run Capacity Control States

The loading & unloading logic in the MAGNUM is as follows: (These may be viewed by selecting 'Status" from the Menu key and using the page down.

1. UNIT IS OFF

This state is entered when the system has moved from a STARTUP, DISABLE, LOCKOUT or LOST I/O state. The chiller is now ready to move into an active state to meet the capacity required.

2. UNIT IS HOLDING

This state is entered when one of three conditions exists:

1) The control sensor reading is being maintained with in the control zone.
2) Control sensor reading is above the control zone but the Rate of Change is less than the value in the (MAX ROC-, #27) Set Point. This indicates that the temperature is decreasing toward the target at an acceptable speed. Therefore, no additional cooling is needed at this time.
3) The temperature is below the control zone but the Rate of Change is greater than the (MAX ROC+, #28) Set Point. This indicates that the temperature is increasing toward the target. Therefore, no reduction in cooling is needed at this time.

This state indicates that there is no need to add or subtract the cooling capacity of the unit. This state will be exited when more or less capacity is required.

3. UNIT IS LOADING

This state is entered when more capacity is required. Every second an adjustment is made to the step delay. When the delay reaches zero, the counter 'steps wanted on' is increased by 1.

4. UNIT IS LOADED

This state is entered when all of the systems available capacity steps are on. The package is providing the maximum amount of cooling capacity.

5. UNIT UNLOADING

This state is entered when less capacity is required. Every second an adjustment is made to the step delay. When the delay reaches zero, the counter 'steps wanted' on is decreased by 1.

6. UNIT IS UNLOADED

This state is entered when all of the systems available capacity steps are off. The package is providing no cooling capacity, as none is required. The system is ready to react to cooling needs.

Appendix D

MAGNUM Run Circuit Control States

The loading & unloading logic in the MAGNUM is as follows: (These may be viewed by selecting 'Status" from the Menu key and using the page down function key to each circuit.). Press the Page down key (Function 3) to view each circuit.

1. CMP ANTICYCE
This state is entered when the PMP DWN State has been completed. The circuit will stay in this state with all circuit points off for the period of time contained in Set Point 59, ACYC OFF to ON and Set Point 63, ACYC ON to ON. The circuit will then move to the OFF State.

2. SWITCHED OFF
This state is entered after the circuit has been pumped down due to the pump down switch being on or if the circuit flow switch is off. In this state the compressor, and all related points, plus the liquid line are off. The circuit will not leave this state unless the pump down switch is turned off. If the pump down switch is turned off, the circuit-state will be changed to the OFF State.

3. UNLD1/HGBP OFF
This state can only be entered for fixed step capacity compressors with a HOT GAS BYPASS solenoid. In this state the HOT GAS BYPASS solenoid is off and all unloaders in the circuit are on.

4. CMP IS AT 100%
This state is when the compressor is fully loaded. In this state, the circuit is providing the maximum amount of cooling capacity.

5. CMP UNLOADED
For infinite step compressors, this state is when the slide is fully unloaded (indicated by unloaded input or after the unloader is pulsed 30 seconds with no change). For fixed step compressors, this state is when the compressor is on and fully unloaded. In this state the compressor is supplying its minimum cooling capacity. For digital scrolls this state is entered when the scroll is at its lowest capacity.

6. HI DISC HOLD
Refer to Set Points numbers 81, HI DISCH PSI; 82, HI DISC UNLD; 83, HI DISC RELD; 87, HI DISCH TMP; 88, HI DISCH UNLD; and 89, HI DISCH RELD.

Fixed Step Compressors -
This state is entered when a fully loaded circuit, that has more than one step, has encountered either a dangerously high discharge pressure or discharge temperature. One step of cooling capacity will be turned off. The circuit will remain in this state for a minimum of five minutes before returning to the LOADED state if the dangerous condition has been corrected.

Infinite Step Compressors -
When capacity is being held due to a high discharge condition, once the discharge returns to normal operating conditions the circuit will return to its appropriate state.

7. HI DIS TMP HLD
Refer to Set Points numbers 87, HI DISCH TMP; 88, HI DISCH UNLD; and 89, HI DISCH RELD.

This state is entered when a fully loaded circuit, that has more than one step, has encountered a dangerously high discharge temperature. One step of cooling capacity will be turned off. The circuit will remain in this state for a minimum of five minutes before returning to the LOADED state if the dangerous condition has been corrected.

8. LO SUCT HOLD
Refer to Set Points numbers 77, LOW SUCTION; 78, LO SUCT UNLD; and 79, LO SUCT RELD.

Fixed Step Compressors -
This state is entered when a fully loaded circuit, that has more than one step, has encountered a dangerously low suction pressure. One step of cooling capacity will be turned off. The circuit will remain in this state for a minimum of five minutes before returning to the LOADED State if the dangerous condition has been corrected.

Infinite Step Compressors -
When capacity is being held due to a low suction pressure condition, once the suction pressure returns to a normal operating condition the circuit will return to its appropriate state.

9. LO TMP UNLOAD
The circuits leaving liquid temperature has caused the system to unload. When the leaving liquid temperature gets to within 1.5 degrees°F of the Freeze Set Point, the unload occurs before we hit the freeze protect safety.

10. LO TMP HOLD
Reload from the 'LO TMP UNL' occurs when we are 3.0 degrees°F above the freeze Set Point. Until we reach this point the system will remain in the LO TMP HOLD State.

11. HI AMP HOLD
Not used with infinite step compressors. This state is entered when a fully loaded circuit, that has more than one step, has encountered a dangerously high AMP draw. Refer to Set Points numbers 65 through 72 for FLA per circuit and 75 HI AMPS %. In this state, one step of cooling capacity will be turned off. The circuit will remain in this state for a minimum of five minutes before returning to the LOADED State if the dangerous condition has been corrected.

Appendix E

MAGNUM Step Delay Integration Logic

MAGNUM Control Zone Control

This control strategy is based upon developing a control zone and then to step the compressor(s) through their stages to maintain the control sensor reading within this zone. To accomplish this the system will constantly monitor the control value, its rate of change and position in relationship to the control zone.

The actual strategy of a fixed step system, reciprocating or scroll compressor, and a variable (slide) step system, screw compressor, digital scroll or a reciprocating or scroll compressor with an inverter, is slightly different. The variable step system allows for infinite variations of capacity while the fixed step system does not.

This option is active in all software and is specified in the **MCS-Config** program.

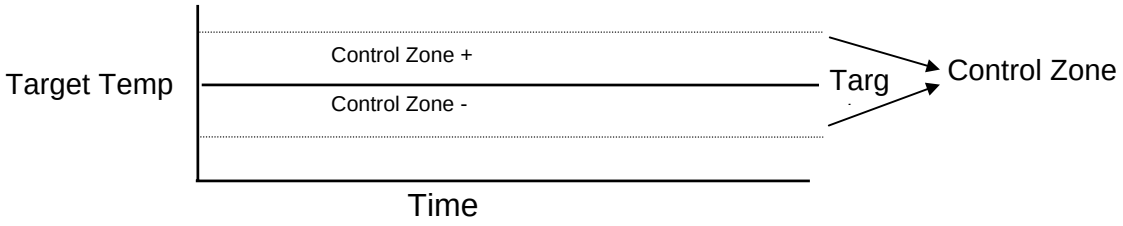
Common Definitions

Target

The control target is specified in set point 1. This will be the base of developing the control zone.

Control Zone

The control zone is developed by adding the set points for the control target (set point 1) and the dead band + (set point 2) to obtain the upper limit. The lower limit is obtained by subtracting the dead band - (set point 3) set point from the control target (set point 1).



Once the control zone has been established, the system will attempt to keep the control sensor reading with in this range.

Controlling Sensor

This is the sensor that has been specified in the **MCS-Config** program as providing the control value reading. It will normally be either the entering, leaving temperature or the suction pressure. The set points must be adjusted to agree with the controlling value.

The Rate Of Change Of The Control Input

The rate of change is how fast the control value is changing over a period of time. If the control value is increasing the rate will be positive, if decreasing the rate will be a negative value. How fast the input is changing, its direction and where the current input reading is in relationship to the control zone will determine what action the system will take.

Step Delay

The system will not attempt to take action until the Step Delay reaches zero. Set point 26 contains the initial value. The speed that it is decrement by is based upon the integration of the absolute value of the area of the Target – The Current Value of the Controlling Sensor, and the sensitivity that has been specified.

Sensitivity

The sensitivity value is contained in set point 25. The purpose of the sensitivity value is to limit or dampen how fast the system reacts to changes indicated by the control sensor. The lower the number, the faster the system will react to changes of the control sensor. This is usually set to 1.

Example

Set Points:

Target = 45º F, Control Zone + = 2 º F, Control Zone - = 2 º F, Step Delay = 300, Sensitivity = 1

Current Values:

Supply Temperature = 55 º F

Using the above values the following would occur:

1. Step delay would reach zero in 30 seconds. Assuming the lead compressor is in the Ready State for 60 seconds it will be turned on.
2. Step Delay is reset to its initial value 300. It is not decremented for 1 minute, State = Hold, to allow the result of the last change to be evaluated.
3. If the slope calculation is less than specified the step delay will again be decremented and the next available compressor will be brought on when it reaches 0. (Assuming it has been OFF and in the Ready State for 1 minute.)
4. Repeated

In the above example, if there is no change in the supply air temperature, the lead compressor would start in 30 seconds. The next compressor would start 90 seconds after the 1st compressor. etc