



Engineering Bulletin

Air-Cooled Series R Chiller – Model RTAC Chilled Water Flow Control

This Engineering Bulletin provides information on:

1. Advantages to the RTAC chiller controlling chilled water flow
2. The algorithm for RTAC chilled water flow control
3. Unit changes to help facilitate evaporator protection
4. What other manufacturers require for evaporator protection
5. Guidelines for specifying chilled water flow control
6. Other prevention steps
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1. Advantages to the RTAC chiller controlling the chilled water flow.

a. **Freeze Protection.** The RTAC has a flooded evaporator, which has a high ratio of refrigerant volume to water volume. This high ratio gives the potential to freeze water inside the evaporator tubes if the refrigerant is allowed to migrate and the ambient is below 32°F (colder if freeze inhibitor is applied). Migration can occur anytime that refrigerant is in the evaporator and the condenser is colder than the evaporator (however, migration causing an evaporator freeze-up can only happen if the ambient temperature is at or below 32°F). The most significant concern for freezing is upon shutdown in very cold conditions, when the condenser will rapidly change from high to low temperature. Migration can also be an issue after long periods of off time when there is a rapid drop in ambient. If the RTAC controls the chilled water flow, it will automatically start the flow in a condition where freeze up is possible, and will keep the flow commanded 'on' until the refrigerant has migrated out of the evaporator, removing the potential for freezing from refrigerant migration. The required chilled water flow control by the RTAC can help protect your customers from freeze damage as well as the associated frustration and cost of repair.

b. **System reliability.** Chiller manufacturers have always preferred that the chiller, or the chiller manufacturers control system, control the chilled water flow because it helps ensure flow. Reliable flow helps prevent nuisance trips and other problems caused by a less reliable flow control system.

2. The algorithm for RTAC chilled water flow control.

The chilled water flow is started when the chiller is put into the "auto" mode of operation. When flow is proven and the water temperature is above the setpoint (plus the differential to start) the chiller will start. At shutdown, the RTAC keeps the chilled water flow on for 0 to 30 minutes, as defined by the customer, but for at least 1 minute if operational pumpdown has occurred. The chiller will also turn on the water flow whenever the temperature sensor in the evaporator reads a temperature at or below the freeze stat setting and the evaporator liquid level sensor concurrently detects a level of refrigerant. The freeze stat setting depends on the percent of brine included in the system. This last function is independent of chiller operation.

3. Unit changes to help facilitate evaporator protection.

Some other changes have been incorporated in the RTAC design to help facilitate the freeze avoidance protection provided by chilled water flow control. At shutdown below 50°F ambient (except for emergency shutdowns), the unit will pump refrigerant from the evaporator to the condenser. To accommodate pumpdown the condenser headers have been redesigned to hold the entire refrigerant charge in the condenser. Pumpdown and the redesigned headers have been incorporated on all RTAC's, starting with Design Sequence B0.

4. What other manufacturers require for evaporator protection.

Every evaporator barrel containing water that is located in an area where ambient temperatures can fall below 32 F (0 C) has the potential for freezing. This freeze potential can be greater for certain air-cooled chillers depending on the evaporator design. A flooded evaporator design allows for higher efficiencies, but also has a higher potential for freezing tubes. Trane, Carrier, and McQuay are some of the manufacturers to use the flooded evaporator design on air-cooled screw chillers.

Carrier does not require flow control on the 30GX. Instead they require a high percentage of glycol for applications where freezing is a concern. The Applications data section of their catalog states, "If chiller refrigerant or fluid lines are in an area where ambient conditions fall below 32°F (0°C), it is required that an antifreeze solution be added to protect the unit and fluid piping to a temperature 15°F (8.3°C) below the lowest anticipated temperature." Though other chiller manufacturers do not require the chiller to control the chilled water flow, they all have the capability, and all manufacturers prefer that the chiller control the flow.

5. Guidelines for specifying chilled water flow control.

There are a few methods for specifying chilled water flow control for the RTAC

- a. Generic –The chiller shall control the chilled water flow.
- b. Proprietary –The chiller shall control the chilled water flow through the following algorithm: The chiller shall start the chilled water flow when put into the “auto” mode of operation. Upon shutdown, the chiller shall maintain flow until the refrigerant charge is no longer touching tubes in the evaporator. During periods when the chiller is off, it shall engage the chilled water flow as required. * Remember – as seen in the Appendices of this Engineering Bulletin, the RTAC does not need direct control of the pumps, simply to provide flow through the evaporator when it is requested by the CH530.

6. Other prevention steps.

Chilled water flow control is a requirement on the RTAC, but there are additional steps you can take to protect the evaporator:

- a. Freeze Inhibitor – A frequent protection method is to include an adequate amount of freeze inhibitor in the chilled water system to protect it from the lowest ambient that the chiller will see. Chiller control of the water flow is still required in these applications because freeze inhibitor may not provide adequate protection in extreme ambient conditions.
- b. Draining Evaporator – If the evaporator is drained before ambient temperatures drop below 30°F, then it is safe from freezing. Chilled water flow control is still a requirement for these applications, because of the danger that an unpredicted change in temperature could arise before draining occurs.

7. Other Considerations.

Flow control freeze avoidance depends on the ability of the evaporator water loop to transfer heat to the evaporator. This ability depends on the amount of heat available in the chilled water loop, which depends on loop size, plus pump heat. For Pump Control to work effectively on the RTAC, two gallons per ton is required. For leaving chilled water temperatures below 42°F, Trane recommends a loop size of 2.5 gallons per ton or greater.



Appendices: Specific Application Issues

A-1: Different Controls Schemes

Specifying the chiller to control the chilled water flow can complicate chiller plant controls, depending on the method of control and complexity of installation. Below are some scenarios for chiller plant controls and how to enable the chiller to control the flow. Make sure the solutions to the following scenarios are also applied to any valves affecting flow to the chiller.

a) Scenario 1: Only the RTAC's CH530 controls the chilled water flow.

A single chilled-water pump feeds the RTAC evaporator and is controlled by the CH530 chilled-water pump relay-output. The building management system (BMS) does not control the pump, but it does turn the chiller on/off.

b) Scenario 2: Trane Tracer controls the chilled water pump wired to the CH530.

A single chilled-water pump feeds the RTAC evaporator and is connected to the CH530 chilled-water pump relay-output. Tracer Summit Chiller Plant Control (CPC) turns on the pump and confirms flow before turning on the chiller. When the chiller is turned off, CPC releases the RTA/RTW Chilled Water Pump Request from ON to AUTO. The AUTO command allows the CH530 to command the chilled-water pump relay ON when conditions indicate possible freezing.

c) Scenario 3: Trane Tracer controls chilled water pumps, not wired to the CH530.

Multiple pumps are headed together to serve the RTAC evaporator. These pumps are controlled by a PCM, UPCM, or other controller and are not connected to the RTAC CH530 pump output relay.

Potential problems with this scenario: Under conditions that may cause freezing, the CH530 on the RTAC will turn its chilled-water pump relay ON to prevent freezing in the RTAC evaporator. Since the pump is not controlled by the CH530, the pump does not turn on and freezing of the evaporator could occur.

Solution:

In the pump control sequence of operation, turn on the chilled water pump for the RTAC chiller if the CH530 chilled-water pump relay-output is ON, or if Chiller Plant Control is requesting the pump. This may be done easily by using an IF statement with an OR operator.

Example: If (RTAC pump relay output is on) or (chilled water pump is requested on), turn RTAC pump(s) on. Remember to control isolation valves accordingly with the pumps.

Applying this solution to Tracer Summit:

A short Custom Programming Language (CPL) statement can be added to look at the CH530 pump relay output to turn the pump on, in addition to the normal pump control. As recommended for best practices, the chiller, pump controller, and CPL routine should be located in and controlled by the same BCU. Further, the pumps and isolation valves should be controlled from the same controller (PCM, UPCM or MP580/1). This reduces communication time and susceptibility to communication problems. Also consider having the pump controller default the pump on and the valves open.

CAUTION

Equipment Damage

It is important that the RTA/RTW Chilled Water Pump Request property not be used in this scenario. If this pump request was used in conjunction with the OR logic suggested in Scenario #3, the pump would never be turned off, and equipment damage could occur.

Example Tracer Summit CPL:
Program RTAC_Pump

```
// Properties Read:  
// Chilled Water Pump Output from  
RTA/RTW  
// Present Value of  
BOP_for_CHW_Pump_Request  
  
// Properties Modified:  
// Present Value of CHW_Pump_BOP,  
// which references PCM binary setpoint  
to control pumps  
  
// Routine Summary:  
/// This routine allows the chilled water  
pumps feeding the RTAC evaporator  
/// to be turned on when the RTAC  
controller detects a potential freeze  
conditions.  
/// The pumps would not turn on in these  
conditions without this routine,  
/// because the pumps are wired to a  
PCM and under normal conditions are  
controlled by CPC.  
  
DEFINT Active = 1, Inactive = 0  
DEFINT Yes = 1  
  
If ((RTAC_chiller).{Chilled Water Pump  
Output}=Yes  
OR  
({BOP_for_CHW_Pump_Request}.{Present  
Value}=Active))  
THEN  
CONTROL({CHW_Pump_BOP},{Present  
Value},Active,5,Set  
ELSE  
CONTROL({CHW_Pump_BOP},{Present  
Value},Inactive,5,Release  
END IF  
  
End // end of routine
```

Appendices:

Specific Application Issues

d) Scenario 4: Non-Trane BMS controls the chiller plan and the pumps

In any RTAC installation with generic manufacturer controls on the chiller plant, it may be necessary for the CH530 to control the pumps in parallel with the BMS controls. This way the BMS controls the pumps or the chiller turns them on as needed for protection. If the parallel contacts are done, any valves that block flow from the chiller will also need parallel contacts to open flow as required by the chiller.

It may be possible to hardwire the CH530 pump control output into the non-Trane BMS and use this to control the pumps as well as any valves. Therefore, the non-Trane BMS is controlling the pumps and valves, but using the CH530 signal when needed.

Chilled water flow control by the RTAC is a requirement on any installation, even if Trane does not control the chiller plant. As a part of the job design, consideration will have to be made for the chiller to be able to control the chilled water flow for any possible final designs.

A-2: 2-Pipe Changeover Systems

For 2-pipe changeover systems it will be necessary for the changeover valve to open upon the chiller's request so a certain volume of water can bleed from the hot water piping to the chiller. A certain amount of bleed through during heating mode is frequently a standard practice on 2-pipe systems and the boiler system will need to be sized properly to account for the increased volume of water when the valve opens. The requirement for bleed-through from the heating side in a 2-pipe system is equal to the minimum published flow rate in the catalog. Adequate bleed through can prevent freezing tubes in the evaporator barrel, the same as controlling the flow. The pump will need to turn on as the chiller requires flow, but the chiller will not need to control the valve.

The main concern for freeze avoidance is based on rapid temperature changes in the RTAC caused by the unit shutting down and/or rapid ambient changes. In

a 2-pipe changeover system the unit will already be off, and the system in 'heating' mode, when the ambient temperature would be a concern. Since the unit is off it should not see a rapid temperature change, except for an ambient change, which is only of concern for very rapid changes. The heat heaters and heat tape will add enough heat to counteract the cooling effect of all but the most extreme temperature drops.

A-3: Valved-off systems

Enabling the chiller to control the pumps does not necessarily mean the flow to the chiller will be enabled. If the chiller is valved off from water flow, make sure the valves will open to the chiller if it calls for flow, except for in the 2-pipe changeover systems described above, or any system where the valve separates the chilled water system from hot water. In any system not involving changeover between heating and cooling, the controls will need to use the chiller signal for flow to open valves necessary to allow flow to the chiller.

For systems with large valved-off volumes, this may mean that flow will need to be ramped-up, and/or valves adjusted to react slowly to help prevent chiller nuisance trips and maintain design supply temperatures. Ramping of flow is not an added consideration for freeze avoidance but should be considered in design. For variable flow systems, with or without valves, the controls may also need to adjust the flow rate based on the freeze avoidance call for flow. The variable flow pump may need to look for the chiller's call for flow to adjust the flow rate high enough to meet the chiller's flow needs as well as that of the rest of the system.

B-1: Frequently Asked Questions:

1. If the RTAC chiller experiences a power loss while running and the ambient temperature is 36 F (2.2 C), will the water in the evaporator freeze?

In this case, the RTAC will experience an unfriendly shutdown. The condenser and the refrigerant in it will quickly arrive at the ambient temperature of 36 F. This means that the refrigerant

pressure should be equivalent to the saturated pressure of HFC-134a at 36 F. The typical refrigerant pressure in the evaporator equivalent to roughly 40 F. With this pressure differential, the refrigerant will want to migrate to the condenser until the pressures are equalized. This equalization will occur when both heat exchangers are at pressures equal to the saturated pressure associated with 36 F. In other words, the water in the evaporator will not freeze, as the refrigerant temperature around that water is at 36 F.

2. If it is 23 F (-5 C) outside and freezing rain causes the power lines to fall down, will the RTAC evaporator freeze?

In this case, the RTAC will experience an unfriendly shutdown. Again, the migration will occur and the refrigerant in the evaporator will experience temperatures similar to what the condenser is experiencing. Thus, the water in the evaporator will be subject to temperatures below freezing (32 F) and have the probability of freezing.

However, this can happen in any packaged air-cooled chiller application. In this scenario, all evaporators with water in them will experience temperatures below freezing and at some point will freeze.

3. I have added glycol to my system, do I still need to have pump control?

While glycol does protect the evaporator from experiencing a freeze condition, Trane does not have control over how much glycol is added. Therefore, Trane still requires to have the chiller controller have a request for flow, even though the fluid is glycol.

4. I drain the evaporator during the winter, do I still need pump control?

Yes, flow control is still required. During the months while the chiller is operational, there could still be weather conditions proving to have temperatures below 32F. In these cases, the chiller would have water in the evaporator barrel and be subject to freezing temperatures without this flow control wired correctly.



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