Slide 1

Hello, my name is Nick Cavitt and I'm a marketing engineer in the C.D.S. group at TRANE.

Today, we will be talking about the Plant Sequencing and Controls focusing on Chiller Plant functionality in TRACE™ 700.

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In this video we will define Sequencing and how TRACE™ uses it, discuss the different sequencing types and learn how to set-up a sequence. We'll also learn the difference between Cooling Equipment Controls and Plant Controls and discuss the different controls options for each. Finally, we'll discuss a few areas where actual controls programming may conflict and be more sophisticated than TRACE™ is capable of directly simulating.

Let's begin by defining what sequencing means in TRACE™.

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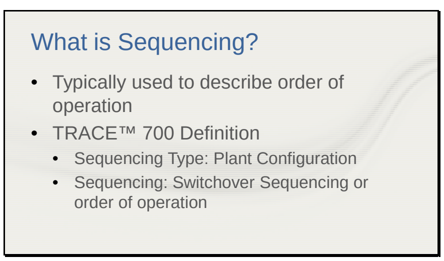

In common practice, the term Sequencing is used to describe the order in which equipment operates or is staged.

In TRACE™ language, we use it to connote two different ideas.

The section where it is most commonly encountered is on the Cooling Equipment tab of Create Plants. There is a Sequencing type field, which defines the hydronic arrangement of your cooling equipment. Simplified, this defines how the cooling equipment operates and handles the load or interacts and shares the load with each other in cases of multiple pieces of equipment within a single plant.

The other usage within the program more closely resembles how sequencing is generally viewed. This is referred to as Switchover

Sequencing in TRACE™ and allows the user to vary how the individual pieces of equipment are staged based on different variables.

We will look at Switchover Sequencing in much greater detail later but first, let's look at the different arrangements or Sequencing Types within TRACE™.

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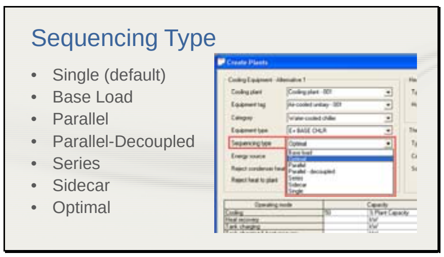

While there are quite a few different and creative pumping schemes utilized in cooling plants throughout the world, TRACE™ uses seven different equipment sequences that are more commonly utilized.

Let's look at each of these sequencing types in a little more detail.

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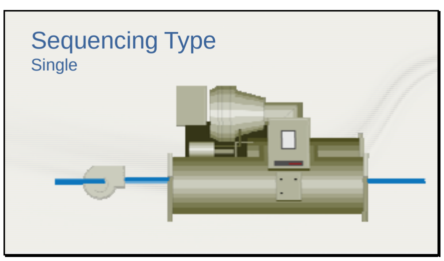

The first type we will discuss is Single, which is the default sequencing type when creating a new cooling plant. The schematic for a single chiller is fairly basic and straight forward; it includes one (1) piece of equipment and one (1) pump. This sequencing type should only be used when there is only a single piece of equipment in the cooling plant.

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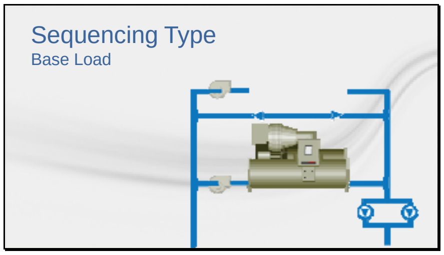

The second type is Base Load. Often seen in scenarios with highly efficient or heat recovery chillers, Base load is used when there is more than one chiller and one of those chillers is defined as the permanent lead chiller. This simulates a scenario where one chiller is always loaded to capacity first and additional chillers are enabled to make-up the difference. This chiller should always be listed first in the sequence list. The simplest way to do this is to create that Base Load chiller first. To base load a chiller in real life usually requires that it be piped in a preferential position on the system. It can be difficult to base load a chiller when all are in parallel without extensive piping and control involvement so if they're all in parallel, a better option may be the next one.

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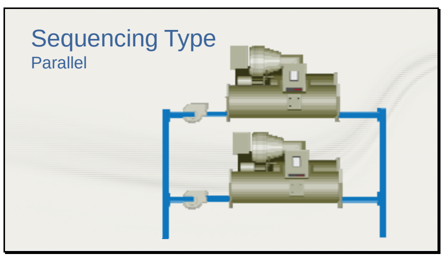

Parallel sequencing indicates chillers piped in parallel. When this sequencing type is used, the first chiller listed will load first and when the maximum capacity is reached for that chiller, the load is then split proportionally in relation to the design capacity of each chiller between that chiller and the next one in sequence. This scenario uses a dedicated pump for each chiller to circulate water throughout the system. This sequencing type can be with both variable speed pumping, variable-primary flow for instance, or constant volume pumping schemes.

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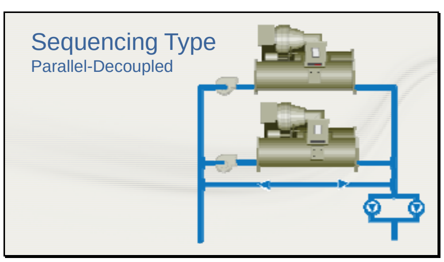

Parallel-Decoupled sequencing has a similar arrangement to the Parallel sequence with the addition of a decoupler or bypass line. It also adds a secondary pump for variable flow distribution to the actual building loads. This scenario is often referred to as a Primary-Secondary scheme and will require you to set up a secondary distribution pump within the Plant Controls. We will cover this option later. This arrangement allows for constant flow through the chillers whenever operating thus eliminating the potential issues regarding system and chiller flow rate or rate-of-change limitations that can result with the Parallel configuration. In addition, all chillers that are operating are loaded proportionally, that is in equal percentages, just like the previously mentioned Parallel sequencing type.

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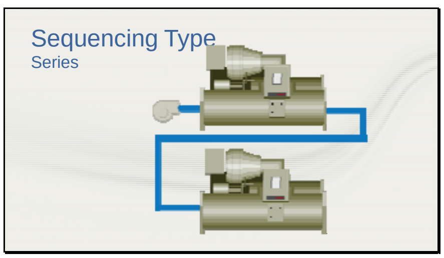

A Series arrangement requires two (2) or more chillers piped in a series configuration with the lead chiller handling the entire load until it's capacity has been exceeded. Once the lead chiller's capacity has been reached, the next chiller in sequence will be enabled to handle the remaining load. Please note, this configuration does not split the load as in Parallel configurations but maintains the full load on the lead chiller with the next chiller in sequence only handling the remaining load.

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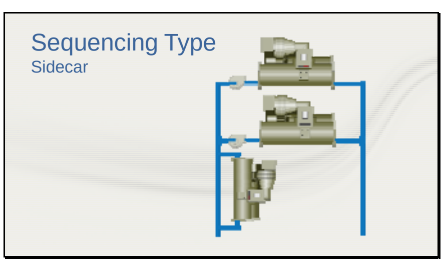

The Sidecar configuration places a chiller or other heat exchanger in the configuration shown. Often these chillers are absorption or heat recovery chillers and they handle as much load as possible. Once their capacity has been met, the remaining chillers will share the remaining load. Please note; there can only be one chiller using the Sidecar sequencing type per cooling plant and, like Base Load, must be listed first.

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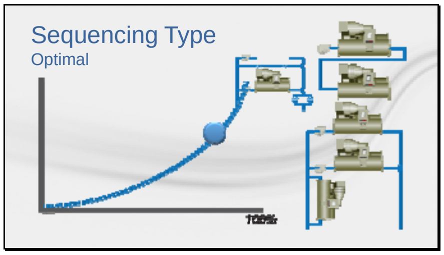

Finally, with version 6.3.2 we have added Optimal sequencing. Using this Optimal sequence allows the program to operate at the best part-load condition using the Power Consumed curve and run the chiller at this point whenever possible. As such, this will set a sort of limit so that once a chiller hits this point, it will maintain this part-load condition and enable additional chillers as required. You will need to have this sequence selected on at least one of the chillers in your plant and either series, parallel, etc. on the other chillers. For more information on this feature and how to implement it, please refer to the F1 Help and the Version 6.3.2 release notes.

It is very important to note that in order for multiple pieces of equipment in a plant to operate no matter what sequence type you've chosen, the capacity for all but the final chiller must be entered. For example, if you have two chillers in a cooling plant, chiller 1 must have a capacity entered in order for chiller 2 to see any load. If chiller 1 has a blank capacity field, TRACE™ will not know what the maximum capacity for that chiller is and will size it to handle all of the load.

Now that we've covered all of the Sequencing Types, let's take a look at the Switchover Sequencing functionality.

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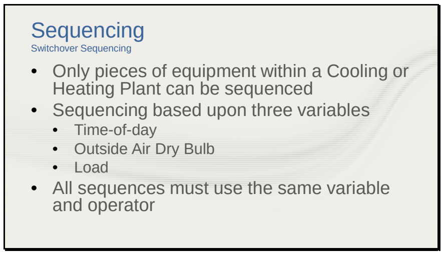

The Sequencing Button allows users to vary the operation of their cooling plants in regards to how equipment within each plant is staged or utilized.

Please note, sequencing can only be done within an individual plant. Multiple cooling plants cannot be sequenced to work with each other. For instance, if you have 2 cooling plants, you cannot create a sequence where Cooling Plant A handles the load from midnight to 1 PM and Cooling Plant B handles the load from 1 PM to the following midnight.

You can only sequence individual pieces of equipment within cooling plants. For example, Chiller-1 would be the lead chiller when the load is less than 300 tons and Chiller-2 would be the lead chiller when the load is 300 tons or greater.

As alluded to, this sequencing functionality can be set-up to change on a number of different variables. Those variables being Time-of-Day, Outside Air Dry Bulb Temperature and Load.

This sequence functionality needs only be used when different pieces of equipment within a cooling plant must vary depending on these variables. The default sequence for most sequencing types as just reviewed will be for the first chiller listed to be enabled first and handle the load until its capacity has been met.

All sequences within a single cooling plant must use the same variable. There can be no mixing of sequence variables.

Let's take a look at how to create a Switchover Sequence using one of these variables.

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Sequencing Screencast

Let's say we want different chillers to be the primary chiller depending upon the Outside Air Temperature.

As you can see, we have three chillers in the Cooling Plant. Let's say we would like Chiller 2 to be lead whenever the Outside Air Dry Bulb temperature is cooler than 70 degrees Fahrenheit, Chiller 1 to come on first when it's between 70 and 85 degrees and Chiller 3 to be the primary anytime it's over 85.

To access the Switchover Sequencing functionality, highlight the Cooling Plant you'd like to apply the sequencing to and click the Sequencing button on the Configuration Tab.

Once you've done this, a new window will appear and you will see that the default sequence will be in the order in which the pieces of equipment are listed on the Configuration tab.

Let's start by creating the three different sequences. To start, highlight and click the delete key or simply select the blank space for each piece of equipment. Then select the order in which the equipment will come on. Since chiller 2 will have priority up to 70 degrees, let's select it first and maintain the order after that choosing 3 and then 1. Once that third chiller has been selected, you'll notice the next sequence line is created. Let's use this line to define the order for temperatures 70 to 85 which will be chiller 1 and then we'll use chiller 2 and then three will be last again. For the third sequence we'll start with chiller 3 since it will operate as the primary chiller anytime we are over 85 degrees.

Now that we have our sequences defined, let's set-up the variable and table to determine when each sequence is used.

When creating these tables, you will need to determine which operator, less than, less than or equal to, greater than or greater than or equal to you'd like to use. The reason for this is due to the fact that TRACE™ locks in the operator once chosen to avoid gaps in your equipment operation.

Let's choose greater than as our operator. When using this operator, you'll want to start with the lowest temperature first and work up from there. Please note, if using the less than or less than or equal to operators, the opposite will be true and you will want to start with the highest value.

Since the weather location we've chosen is in a heating dominant climate, we'll start with a significantly low temperature to ensure there are no gaps. If unsure where you should start, you can check your weather data to ensure you are starting with a low enough or high enough temperature.

Since we are starting with our coolest temperature, we will start with the first sequence created. In the sequence column, we'll select that first entry, then select the greater than operator and finally, we'll enter that lowest temperature and corresponding unit. Once that has been created, we can move to the second line and select the second sequence. You'll notice that on this second line, the operator cannot be changed. We will then enter that 70 degree temperature and we will then move down to set up the final line which will define the third chiller as our primary anytime it's over 85 degrees outside. You will then want to make sure to click OK to ensure that sequence is saved.

There you have it, we've defined a Switchover Sequence based upon the given temperatures.

To delete the sequencing, simply highlight either the sequences in the upper or lower areas and click the delete button.

Next, we'll talk about the features within Cooling Equipment Controls.

Cooling Equipment Controls are accessed on the Cooling Equipment tab. Since these are specific to an individual piece of equipment, the proper piece of equipment must be selected in the Equipment tag field. Once you have selected the proper equipment tag, simply click the Controls button along the right side of the window.

Again, these are for individual pieces of cooling equipment. We will cover controls for an entire plant next.

Once you have clicked this button, you will see a new window appear with a number of different configuration options which we will now review.

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Cooling Equipment Controls relate to specific pieces of equipment so if when trying to apply these strategies to multiple chillers, you will need to set-up these controls for each chiller or, alternatively, you could set-up the first chiller completely and then copy that chiller.

Among the options we are going to discuss are Free Cooling, Evaporator and Condenser Water Leaving Reset Options and
Load Shedding Economizer. We will also touch on how the Equipment Schedule affects plant operation, how Demand Limiting Priority functions and the Design Chilled and Condenser Water Delta T overrides.

Options such as Evaporative Pre-Cooling and Hot Gas Reheat for Dehumidification will not be covered. However, look for these features to be discussed in future videos and as always, you can find additional information using the F1 Help.

Let's take a look at each of these options in detail.

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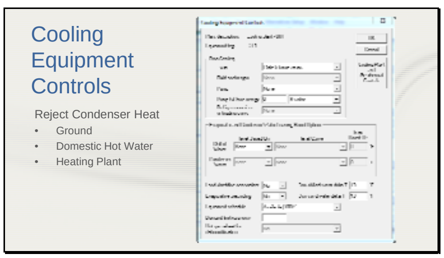

Upon clicking the Controls button on the Cooling Equipment tab, you will be presented with this window which allows for each of these options to be configured.

Free Cooling allows for different water-side economizer techniques to be applied to individual pieces of equipment. For more information on each of the different free cooling methods offered, please use the F1 Key to bring up the Help documentation which includes a write-up on each Free Cooling scheme.

The Evaporator and Condenser Water Leaving Reset Options fields allow users to reset the temperature leaving the Evaporator or Condenser based upon the Outside Air Temperature or the temperature of the water returning from the building. Condenser Water Reset is only available with heat recovery applications. Changing the condenser water temperature entering the typical chiller is accomplished on the Options tab of your Cooling Equipment library member.

To use the Condenser Water Reset feature, a chiller must be selected and the Reject Condenser Heat field must be set to Ground, Domestic Hot Water or Heating Plant. For both Evaporator and Condenser Water Reset, a Reset curve must be selected if basing the reset upon outside air temperature and if basing the reset upon return water temperature, the Max Reset TD or Temperature Difference field will be used. Please note, this is not the same as

Condenser Water ENTERING Reset which is not a specific feature but can be accomplished to a certain degree using the Hourly Ambient Wet-Bulb Offset field associated with the Heat Reject equipment.

Load Shedding Economizer is a heat recovery concept. This strategy uses an airside economizer to control the cooling load on a heat recovery chiller so that the heat recovered from the condenser matches the heating demand. If this option is enabled, the airside economizer in Create Systems should not be used. Additionally, this option can not be used for all equipment. Please refer to the F1 Help and the User's Manual for more detail.

The Equipment Schedule functions in a similar fashion as any other schedule in the program. This field does not set a limit on how much the equipment will load but rather what availability for the piece of equipment is when required to run. For instance, if the load on a 1000 ton chiller is 100 tons for a given hour but the schedule during that hour is set to 50%, then the chiller will only produce 50 tons. Typically, we recommend not changing this from Available (100%) unless you have a scenario where the equipment should not run or if you are modeling thermal storage which requires the schedule to be changed to one that allows for thermal storage. The default Available (100%) schedule does not allow for thermal storage.

The Demand Limiting Priority field simply allows the user to set the priority in which equipment will be disabled should the Maximum kW Demand of the building be exceeded as set in the Energy Management section of Create Plants. For instance, a priority of one means it is the first piece of equipment limited. Up to 10 pieces may be demand limited.

The Design Chilled and Condenser Water Delta T fields override the corresponding fields as set in the Cooling Equipment Library and are only available for air-cooled and water-cooled chiller equipment. These values are used to determine chilled and condenser water flow rates at design conditions as well as Part-Load chilled water entering and leaving conditions and the Design condenser water leaving conditions.

Next, we are going to look at the controls options for an entire plant.

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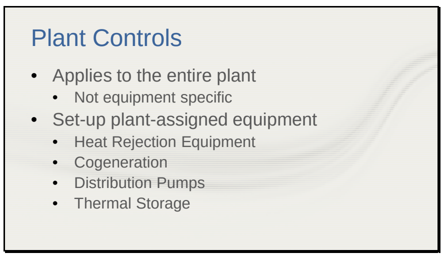

As mentioned, the Plant Controls apply to the entire plant and are not specific to any one piece of equipment within that plant.

The user is able to define the sizing method as well as set the parameters for any equipment serving the entire plant such as a shared Cooling Tower, a building Distribution Pump as used in a Parallel-Decoupled or Primary-Secondary and Variable-Primary pumping schemes for example or a Geothermal Well Field.

Let's look at the options on this screen in more detail.

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Plant Controls Screencast

There are two ways to access the Plant Controls. The first is via the Configuration tab. Start by selecting the plant you would like to modify the Plant Controls options for and click the Plant Control button along the right side of the window. You can also access them through the Cooling Equipment Controls window by clicking the Cooling Plant and Geothermal Controls button.

The Sizing Method field allows for the user to select the methodology used to size the Cooling or Heating Plant.

The methods to choose from for Cooling Plant sizing are Block Based on Design Simulation, Block Based on System Simulation and Peak Based on Design Simulation.

Block Based on Design Simulation sets the plant capacity equal to the sum of the block capacities of the airside cooling coils assigned to the given plant as calculated during the Design Phase.

Block Based on System Simulation sets the plant capacity at the sum of the highest block load for the assigned airside cooling coils as calculated during the System Simulation.

Peak Based on Design Simulation sets the plant capacity to the sum of the assigned airside cooling coil capacities

The methodologies to size a Heating Plant are either Block Plant or Peak Plant. Both are sized during the Design Phase.

Block Plant sets the Heating Plant capacity at the sum of the block airside heating coil capacities.

Peak Plant sets the plant capacity equal to the peak capacities of the airside heating coils.

The Heat Rejection fields set the parameters for Heat Rejection equipment assigned directly to the Plant. For example, if you have a cooling tower that is shared by three water-cooled chillers, you would delete the cooling towers that are assigned to each chiller and drag a cooling tower directly onto the plant. This cooling tower would then be shared by all three chillers and you would set the Type and Hourly Ambient Wet Bulb Offset on this Plant Controls window.

This same principle applies to the Cogeneration, Secondary Distribution Pump and Thermal Storage options. All of these fields pertain to the options assigned to the plant as a whole and are not specific to any pieces of equipment within the Plant.

Please note, Cogeneration can only be set-up when accessing Plant Controls for a Heating Plant

The Geothermal Loop field offers similar functionality and you can find much more in-depth detail on it in our video on Ground-Source Heat Pump Systems. Please note that there can only be one Geothermal Loop per Alternative. Even if there are multiple Plants within a given Alternative, only one of those plants may have a valid Geothermal Loop set-up.

I'd now like to highlight a few instances where TRACE™ modeling and some Real World scenarios conflict.

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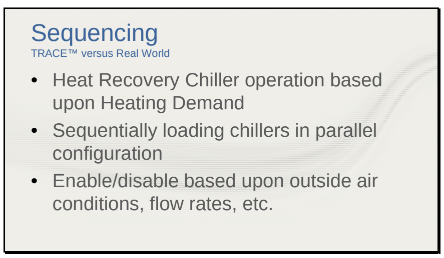

While TRACE™ does have quite a bit of flexibility, there are a few real world sequences that the program is not able to simulate.

For instance, when modeling a heat recovery chiller, the chiller is only able to operate based upon cooling demand. Recovered heat is a byproduct of this operation. The chiller will not become enabled nor operate to maintain heat requirements if there is not enough cooling load to supply the required heating BTU's.

Additionally, if you are looking to sequentially load chillers in a parallel configuration, TRACE™ is unable to model this scenario. The parallel or parallel-decoupled configurations only operate as previously discussed with the chillers operating in tandem and ramping up and down to share the load. The program is not able to maintain the full load chiller operation on the primary chiller and gradually load the second chiller to meet demand.

However, in real life it is very difficult to preferentially load a chiller piped in parallel with other chillers as previously mentioned, so TRACE is likely to be very close to reality in this case.

As such, the only way to sequentially load chillers is to use the Series Sequencing Type.

Also, enabling and disabling chillers based upon different variables such as outside air conditions other than temperature, flow rate, etc. is not a possibility. As mentioned when we discussed Switchover Sequencing, the only variables available are outside air temperature, load and time-of-day. You may be familiar with the Reset and Lockout table functionality within schedules however, this feature is not available for Equipment Schedules.

In a similar vein, chillers can only be disabled in the order in which they were enabled. For example, if the chillers were enabled in the order of A, then B, then C, C will be the first one to be disabled, then B and then A.

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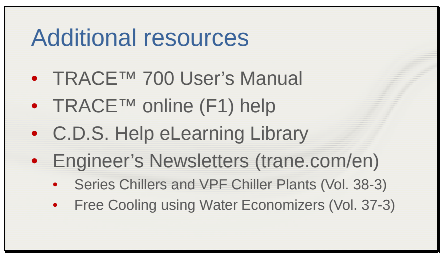

That covers Chiller Sequencing and Controls. Hopefully, we've answered any questions you have on these features but if you would like more detail on this or any other elements of TRACE™ 700, here are some additional resources available to you.

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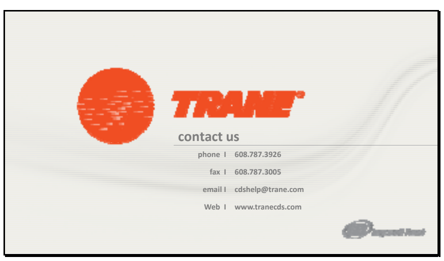

As always, please feel free to contact the C.D.S. Support Center by phone or email with any comments, questions or modeling issues you may be experiencing.

Thank you for your time and we wish you continued success.