Commissioning Cooling Towers

Checklists for design, construction, and startup

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Like most other HVAC equipment, the commissioning of cooling towers starts during design and continues on through construction, start-up, and operation.

DESIGN CHECKLIST

The following issues often show up as construction, start-up, or operational issues if they are not addressed early in the process. These items can be used as a checklist in your next cooling tower commissioning project.

Consider electronic level control in place of float valves to minimize valve maintenance and provide more reliable level control. This approach also allows the makeup connection to be located inside, eliminating heat trace and other freezing weather concerns for the makeup line. High- and low - level probes usually are easy to add to the holder containing the normal level - control probes. When heat trace, insulation and piping costs are taken into consideration, this approach often has the additional advantage of a lower first cost as compared to a float valve.

Consider metering the makeup and blow down flow rates. Many water treatment systems require one or the other of these flow rates for proper operation, and most water companies will reduce your sewer charges if you can document how much of the makeup water was lost to evaporation instead of discharged to the sewer. Include properly located provisions for water-treatment system sensing probes and water -treatment chemical injection fittings.

Consider freeze protection approaches that don't use electric heat. Certain systems can use steam, hot water, or low - temperature waste heat from the condenser of an operating chiller, all of which use less energy than electricity (both at the meter as well as the source). If cleverly applied, it is possible to eliminate heat trace and insulation for the exterior piping with this system, especially in milder climates. In many cases, when all costs are considered (electric heating elements and associated wiring, interlocks and associated wiring, heat trace, insulation) the alternative approach will have an equivalent or lower first cost in addition to lower operating costs.

Consider the following monitoring and control points in addition to those needed by the control sequence:

- Vibration alarm.
- High - level alarm.
- Low - level alarm.
- Makeup flow accumulation.
- Blow down flow accumulation.
- Basin heater and heat-trace proof of operation.

These points and associated alarms, when properly applied, will prevent damage due to fan imbalance or drive train problems, flooding of areas below the tower, loss of water-treatment control, pump and basin heater damage, unanticipated chiller outages, unnecessary energy use, and reduced sewer charges.

Consider using a rigid averaging temperature sensor arranged to average basin temperature over the depth of the basin for the input to the control loop instead of a pipe-mounted sensor in the discharge line. Tower basin temperatures can stratify, especially with deep basins and non-variable speed fans. When the fan runs, a cool layer of water is created. When the fan shuts down, a warm layer of water is created. As a result, a sensor in the line leaving the tower will tend to see a step change in temperature as the water in the warm layer exits the basin and is suddenly replaced by water from the cool layer. This makes the control loop unstable and difficult to tune. A sensor that averages temperature over the basin depth will smooth out the input to the control loop and provide more precise control with less fan cycling.

Consider specifying performance testing per Cooling Technology Institute standards. Don't forget to include the necessary wells and sensing points required to accommodate these tests. Information on these standards and requirements can be found at *www.cti.org*, as well as other useful information regarding cooling-tower design, construction, installation, and operation.

Prime and paint the condenser water piping, cooling tower structural steel, and other exposed metals to ensure long life and a neater appearance. Consider color-coding the lines, especially on complex piping systems.
Where piping serves multiple towers, arrange the piping so that supply and return connections to each cell and each connection point are symmetrical and, thus, self-balancing.

For multi-cell towers, include isolation valves in the equalization connections between cells, in addition to the supply and return lines so that individual cells can be taken out of service for cleaning without shutting down the entire system .

Make certain that the pump selections are non-overloading for systems with multiple pumps sharing common piping circuits to pre vent nuisance overload trips when the pumps run out their
curves if the system is running at less than peak flow.

Include a gauge connection ahead of any strainers or screens located on the suction side of the pump to allow operators to monitor strainer pressure drop and avoid NPSH problems caused by a dirty strainer.

Include access such as ladders to fan decks and hot basins, internal access platforms, and stairs and catwalks over and a round roof-mounted piping to enable good operation and maintenance. Coordinate with local and OSHA safety requirements for tie-offs, railings, and ladder enclosures.

Make sure that both the tower and its mounting and support systems are designed for the seismic loads associated with the location. Keep in mind that standard mounting rails often are inadequate for seismic loads.

Coordinate with the local community during design to ensure that the installation complies with any local requirements. Issues typically involve visual and sound requirements. You don't want to
find out that there is an Architectural Review Board for the neighborhood when a lawyer contacts you after the tower has arrived on site.

For locations where sound is an issue, consider:

- Over-sizing the tower to minimize fan speed at design conditions. This can have some positive energy impacts that might help offset added first costs.
- Using a variable-speed drive instead of a single-speed or multi-speed motor to minimize fan noise, both at less than design conditions and when a load change results in a motor-speed change.
- Using architectural acoustically rated louvers to minimize the sight and sound impact of the tower.

For locations where visual appearance is an issue, be sure that any louvers or other screening devices are located in a manner that does not interfere with tower air flow and, thus, degrade its performance. Possible problems include enclosures that restrict the flow into or away from the tower or create a flow pattern that causes recirculation from the discharge to the inlet. If you are forced into either of these situations, you may have to oversize the tower or take other steps to obtain the desired level of performance.

For **multi-cell installations**:
Consider a control sequence that flows water over all tower cells regardless of the load if the ambient temperature is above freezing to minimize tower energy consumption. Implementation of this operating mode will provide significant energy savings due to reduced fan operation. However, this mode is a bad idea when temperatures are below freezing because the fill will ice up much more quickly than it would if design flows were maintained across the cell. Some manufacturers will not certify performance in this mode regardless of the ambient temperature. If you anticipate using this approach, you should review it with the tower manufacturer prior to implementation to determine if there are any operating limitations that need to be considered.
For multi-cell installations, consider a control sequence that runs the fans on all active cells on low speed before switching any fan to high speed to minimize energy consumption.

Consider seasonal extremes in addition to statistical norms when selecting your tower and developing its operating sequence. This is especially important for towers that must run year -round and/or serve critical applications. If your tower will operate year - round, and your location can see subfreezing weather, then the installation needs to be designed to deal with it, even if the statistical design conditions are above freezing. It doesn't take many hours of operation below 32 F to convert a tower cell to a large ice cube

Consider the chiller's minimum allowable entering condenser water temperature when you design your installation and control sequence. Even if your chiller only needs to run when outdoor temperatures are above the mid 50s F, the basin water temperatures in the idle tower will probably be lower than the machine can tolerate. This can cause start-up problems unless the system has been designed to deal with it by recirculating water inside the building to use the chiller's rejected heat to warm up the system.

Make sure that your control sequence specification sequences the tower bypass valve with the fan operation to prevent operating the fans with the bypass valve open.

For towers that must operate in subfreezing we a t h e r, make sure that your control sequence specification:

- Reverses all cells at the same time to prevent the discharge from one cell being circulated back through the adjacent cell and icing up the fan blades.
- Includes accommodations that allow it to be easily tuned to meet actual operating conditions.
- Operates the bypass valve as a two position valve in subfreezing weather to mitigate fill icing problems.

For towers with **multi-speed motors: m**ake sure that the control sequence reflects the need for a time delay when switching from high to low speed. Ideally, the system should execute the time delay no matter how the speed is switched—manually via selector switches, automatically by the control system, etc. Additional interlocks to prevent inadvertently energizing the high-and low-speed windings at the same time are also desirable. Using a Form C contact to make the high-low speed switch is also helpful in this regard.

For **field-erected towers**, make sure that the contract documents adequately reflect rigging and assembly requirements to avoid problems with change orders later.

Verify that fire sprinkler requirements (if any) are included and coordinated with the other fire protection requirements for the project. This is usually an issue with large field-erected towers made of wood or containing significant volumes of other flammable materials such as plastics. You should consult the building's insurance underwriter in addition to the local code officials to determine sprinkler requirements. The underwriter's requirements may be more stringent than those of the code officials.

CONSTRUCTION CHECKLIST

Make sure that the shop drawing for the tower that will actually be supplied indicates that the tower will meet all of the project requirements including temperatures, flow rates, weights, fan bhp, sound power, clearances to obstructions that could restrict airflow, etc.

Make sure that the control – system shop drawing reflects the point and operating sequence details in the manner intended by your design.

Meet with the pipe fitter early in the project to make sure that the details associated with the installation are clearly understood, including piping arrangements and instrumentation port requirements.

Have the firm performing the performance test review the field installation several times during the fabrication process to make sure that its needs for certification testing are accommodated correctly.

Perform field inspections several times during construction to verify proper design implementation and be proactive in resolving issues that arise due to existing or hidden conditions.

STARTUP AND OPERATIONS CHECKLIST

- Verify that the overall installation reflects the requirements of the plans, specifications, and manufacturer's installation manuals.

- Verify that the minimum speed settings on VSDs have been coordinated with the requirements of the cooling - tower drive train. This can be especially important for towers with gear boxes that use splash-lubrication approaches .

- Verify that the sensor that the control system used to sequence the fans and bypass valve is located downstream of the point where the bypass water mixes with the water coming from the tower basins.

- For multi-speed tower fans, verify that :
  - The time delays provided for speed changes are adequate to pre vent drive -train problems when switching from high to low speed.
  - The interlocks pre vent simultaneously energizing high and low speed function.

- Verify all safety interlocks work properly.

- Verify system and control loop performance and stability at all load conditions (cool and dry, hot and humid) and flow conditions (smallest pump on, all pumps on). As with most commissioning processes, some of the testing, tuning, and adjustment will occur over the course of the first operating year.

- For towers that must operate in sub - freezing weather, verify that:
  - De-ice cycles are adjusted to minimize the time spent in re verse, but adequately melt ice accumulations from the intake side of the fill under all temperature conditions.
  - The bypass valve operates as a two position valve when it is below freezing.

- Verify that basin heaters and heaters systems are shut down when the temperatures rise above freezing.

- Verify that seismic restraints have been properly installed and adjusted.

- Verify certification test results indicate that the tower is performing per specifications.

- Verify that start-up screens have been removed from the strainers and replaced with gravel screens. Start-up screens are designed to assist with cleaning and flushing of the piping systems subsequent to installation and thus, are usually of a fairly fine mesh. If a condenser-water system is operated with these screens, they will often foul and cause nuisance problems including NPSH/cavitation problems at the pumps and head pressure problems at the chiller. Replacing these screens with course screens selected to retain only materials that could damage pumps or plug tubes will minimize these nuisance problems and save some energy, too, because the strainer pressure drop will be lower.