



## Niagara Blower Heat Transfer Solutions

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Q: How is the WSAC a closed-loop cooling system?

A: The WSAC is a closed-loop cooling system because the process loop being cooled is inside the tube bundles of a WSAC. The recirculating spray water is sprayed on the outside of the tube bundles creating the evaporative cooling effect and never contacting the process water/fluid inside the tubes.

Q: Why a closed-loop cooling system?

A: 1. Open-loop cooling tower water is exposed to airborne contaminants (dust, dirt, algae/biological organisms). This is then transported to the heat exchanger, where fouling can jeopardize proper heat transfer performance.

2. Closed-loop recirculating coolant can be anything. This assures that freezing will never occur anywhere within the closed loop.

3. Open-loop spray water on the WSAC is virtually freeze proof. Only when zero process load conditions exist can there be any freezing. This is easily protected against by using small immersion heaters to maintain a demand-ready system.

4. Temperature control using closed-loop is more assured.

Simple RTD monitoring of outlet fluid temperature can be combined with logic control of fans to effectively modulate heat rejection capacity of the WSAC. VFDs can be supplied for even better temperature set-point control during fluctuating ambient conditions. Inlet vs. outlet temperature monitoring (delta T – cooling range) can permit capacity control functions to further improve response times (set point control).

By contrast, cooling tower temperature control is more temperature-range limited with higher transient response times due to large volume of water in the circulating loop. Fan control will only be effective at capacity control at high-range of wet bulb conditions. At low ambient conditions, a CT will still evaporate a certain percentage of water even with fans cycled off. Thus, the water temperature will continue to ramp down if not balanced by heat load from the plant. Complete tower bypass yields pump head inefficiencies unless VFD control of pumps is provided.

Freeze protection of CT loop is large concern due to large volume of water contained in the system. Kw consumption may become copious to maintain a thawed basin condition.

5. Closed-loop evaporative coolers consume less parasite energy than CT for same heat rejection. Typical fan horsepower reduced by 10-25%. Typical pumping horsepower reduction of 10-40%.



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6. Water savings; a WSAC can operate at higher cycles of concentration leading to lower make-up and blow-down rates. This represents best use of water for facility water balance.

A WSAC can be designed to allow cooling capacity without evaporation of water (wet/dry system). Finned tube bundles, spray water zone cycling are both viable options to consider. Water conservation is the big benefit of these upgrade options. This is not possible with a CT system.

### **Aftermarket Parts/Customer Service**

Q: Does Niagara supply original parts for older equipment?

A: Yes - Niagara maintains all original equipment design and manufacturing details.

Q: Does Niagara provide system evaluations, service and/or on-site training?

A: Yes - Niagara's trained and experienced technical staff will help ensure that your WSAC system continues to operate for many years to come with little maintenance. Just like any other mechanical system, proper operating procedures and maintenance practices are important. A well maintained system will minimize energy use, reduce operating and maintenance costs, and increase component life.

### **Drift, Plume & Fouling**

Q: How do drift eliminators work on a WSAC unit?

A: Drift from an evaporative cooler is produced when moving air entrains small droplets of water during direct contact, and discharges them along with the saturated air. These drift droplets have the same water chemistry as the circulating spraywater in the WSAC unit.

Drift eliminators function by causing the water droplets to impact on a solid surface where they lose velocity, collect and drain back into the circulating flow stream. Most modern drift eliminators cause the saturated air to change direction three times to achieve an optimum drift removal process. They can be installed in a horizontal or inclined plane to provide complete coverage so that no air can bypass around the panels. Construction is PVC panels formed of corrugated



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sheets that produce a cellular media causing minimal pressure drop while accomplishing the desired result.

The circulating (spray) rate of a WSAC is much less than an open cooling tower and the corresponding drift amount is much less. Drift eliminators (DEs) can be added to a WSAC to further reduce the quantity of drift emitted during operation. Typical guaranteed drift rate in a WSAC with DEs is 0.005% of the circulating water flow rate; without DEs is 0.02%.

Q: How does the plume from a WSAC compare to that of a cooling tower?

A: It is best to start with a brief definition of plume. For cooling towers and Wet Surface Air Coolers, the plume is simply the hot, moist air discharge to the atmosphere after the evaporation of a small portion of the circulating water inside the unit. Plume is present any time the equipment is operated; not just in certain conditions when it becomes highly visible. Plume from a WSAC would be very similar to that of a cooling tower. The plume is not a form of air pollution since nearly all of the moisture content is pure water vapor produced by the evaporative effect between the air & water interaction inside the equipment. A small quantity of drift may also be present in the plume air stream which may contain trace amounts of solids since drift is a mechanical stripping of water droplets by the passing air.

Plume is typically not a nuisance until the right set of atmospheric conditions cause it to become visible. The visible effect is produced when the water vapor content of the discharged air mixture condenses out due to interaction with the surrounding ambient air. During winter months when the ambient air is sufficiently cold, the discharge air is cooled rapidly and lowers the plume temperature below the dew point. Thus, plume is primarily visible during winter operation of any evaporative cooler.

Q: We have a lot of experience with other styles of evaporative coolers; why does Niagara say that drift eliminators are not always necessary in the WSAC?

A: Drift eliminators are required on all cooling towers, but are optional on Wet Surface Air Coolers. Because the circulating (spray) rate of a WSAC is much less than an open cooling tower, the corresponding drift amount is dramatically reduced. However, they can be added to a WSAC to further reduce the quantity of drift emitted during operation. Typical guaranteed drift rate in a WSAC with DEs is 0.005% of the circulating water flow rate; without DEs is 0.02%.



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The air in the WSAC makes a 180° turn before it is discharged. This turn acts as a gravity separation to drop out most of the large droplets before being discharged.

Q: Our refinery is in an area where plume is frowned upon. Can Niagara provide plume abatement?

A: Yes - There are several techniques used to further reduce or abate the plume. The nature of the WSAC allows for simple and cost effective modifications such as:

a. Partial Wet/Dry Operation: When operating at wet bulb temperatures below design, the WSAC can be designed to operate partially dry. This means that the spray water can be shut off over one entire tube bundle for fluid cooling applications or a portion of all of the bundles for condensing applications. This allows for the air in the basin to be sensibly heated by the dry portions of the bundles and part of the air stream can be kept less than 100% relative humidity. The exiting (non-saturated) air stream will disperse at a faster rate than the saturated air stream, thus reducing the visual affects of the plume.

b. Cold Air Introduction: Cold ambient air is induced through a series of louvers, into the WSAC basin. This causes some of the water vapor in the saturated air stream to condense and lowers the absolute humidity of the saturated air stream. This lowers the water vapor density in the exiting air stream, which reduces the visual affect of the plume.

c. Reheat Coils in WSAC Basin: Finned reheat coils can be installed in the WSAC basin to sensibly heat the saturated air stream to keep the air at less than 100% relative humidity. The exiting non-saturated air stream will disperse at a faster rate than the saturated air stream, thus reducing the visual affects of the plume. The coils are typically stainless steel tube and aluminum fin and will be one or two rows deep. The coils can be heated with either steam or hot water.

Q: How does the Niagara Blower Wet Surface Air Cooler (WSAC) deal with fouling?

A: Fouling can potentially occur in two mutually exclusive areas on a Niagara WSAC, internally and externally. Internal fouling can occur within the closed loop (inside the tubes) due to the properties of the process fluid. External fouling deals with the exterior of the tubes, generally due to the properties of the spray water.



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Internal Fouling (closed-loop) - WSAC units address the key aspects of design that will efficiently cool a fluid high in solids without routine fouling problems. This system is “closed-loop” which means that the process stream being cooled or condensed is never exposed to the spray water or to the ambient air where it can be contaminated. When designing a WSAC the tube bundle material is selected for its resistance to fouling (ex. Stainless Steel for its smooth surface and corrosion resistance) and conservative fouling factors are used. Tube bundles are also designed to maintain sufficiently high internal fluid velocity to prevent solids from falling out of suspension and create a washing or flushing effect inside the tubes. Removable dome covers can be used for ease of tube cleaning and planned maintenance. Blind flanges are used for access on each header pass allowing for easy visual inspection. The interior of the tube bundles can be completely cleaned, in place, without removing the bundle from its installed platform while adjacent tube bundles on the same platform can remain in service. A pressure gage can be installed on the header of each tube bundle pass (increasing pressure would indicate restrictions). Tube bundles can be individually valved for isolation/cleaning/inspection while the balance of the unit remains operational.

External Fouling (spray water system) - The spray (makeup) water system of the WSAC can utilize a wide variety of water sources including blowdown, effluent, treated wastewater, etc. The spray water is pumped at high drenching flow rates. In conjunction with low pressure/high volume spray water, the WSAC unit is designed with concurrent flow (spray water and air flow in same direction) and wide tube spacing to maintain the water film on the outside of the tubes and minimize external fouling of the tube surface (this assures uniform heat transfer and integrity of the design overall heat transfer coefficient).

### **Water Evaporation & Makeup**

Q: Untreated blowdown water from other equipment is commonly used as makeup water to the WSAC. It appears that with a higher number of cycles of concentration, you can reduce the makeup water requirement, but if the evaporation load is about the same as a cooling tower, which is 80 to 85% of the total makeup requirement, the maximum savings in makeup water for a WSAC over a cooling tower is probably less than 10%. Is this correct?

A: Yes - The maximum savings in makeup water will be no more than about 10%. However, keep in mind that if there are existing cooling towers on site, the WSAC can use the blow down from those towers as makeup. No new or



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additional source for makeup water is required in this case. This allows for an overall reduction in water usage.

Q: Is that the evaporation load for a WSAC is about the same as for a cooling tower?

A: Yes - The evaporation load for a WSAC is about the same as for a cooling tower. However, the advantage of the WSAC is a single approach to the wet bulb for the process being cooled. With a cooling tower and heat exchanger system there are two approaches; one approach in the tower and the second approach in the heat exchanger. The single approach makes the WSAC a more efficient cooler.

### **WSAC Components (Sprays, Fans, Coils, Tube Bundles, etc.)**

Q: Our Niagara WSAC is 28 years old, we would like to upgrade to the new style of spray system, is this possible?

A: Yes - However, new spray pipe supports are necessary.

Q: How does Niagara pressure test the tube bundles?

A: Niagara performs a hydrostatic pressure test on the entire tube bundle. A liquid dye penetrant test is performed on each individual tube-to-tubesheet joint.

### **Temperature**

Q: What is the minimum economical cooling water supply temperature for a wet surface air cooler? Your website says you can get to 5 F above the wet bulb, but is this economical?

A: The minimum practical or economical cooling water supply temperature for a Wet Surface Air Cooler is 10 F above the wet bulb. A WSAC can get as close as 5 F to the wet bulb, but the size and cost increase substantially.

Q: How can the process fluid outlet temperature be controlled to maintain a set point value?



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A: Like all evaporative coolers, a WSAC is sized to reject heat at the most difficult condition (full heat load at the highest expected inlet wet bulb air temperature). Because most of the operating time will involve “off design” conditions (partial heat load and/or lower air wet bulb temperature) it becomes necessary to control the WSAC heat rejection capacity for cooling applications that require a set point (or range) of outlet fluid temperatures.

Changing the air flow rates over the tube bundles effectively controls the fluid outlet temperature in most cases (not decreasing the spray rate). Multiple fans operating in parallel are used to induce the required air volume needed to evaporate the application’s heat load (as opposed to a single large diameter fan). This allows utilization of a number of different process temperature control schemes. Listed below are three options that we would consider good, better and best for controlling the process outlet temperature.

a. Good: Fan Cycling - The WSAC fans are operated in On/Off mode with the fans automatically switching off when the process outlet temperature begins to drop due to lower heat loads or reduced wet bulb temperatures. There are multiple fans so the control has many digital steps. This system can keep the outlet temperature at  $\pm 0/-5$  degF relative to the set point. This is the most economical solution as all that is required is a temperature probe on the process outlet piping

b. Better: Damper Control (with or without VFDs) - The most precise way to control the fluid outlet temperature would be to install modulating dampers on the inlet air-side of the WSAC coil. For units with multiple cooling services having separate cooling coils, dedicated dampers can be supplied for each coil. The dampers would slowly close as the process outlet temperature begins to drop due to lower heat loads or reduced wet bulb temperatures. This is also an analog control scheme that would require a simple temperature controller or an added PID loop in the PLC. Because this is a very precise control scheme, the outlet temperatures can be maintained at  $\pm 0/-1$  degrees F relative to the set point for most applications.

c. Best: Variable Frequency Drives (VFDs) - VFDs can be used to reduce the fan speed when the process outlet temperature begins to drop due to lower heat loads or reduced wet bulb temperatures. This is an analog control scheme that would require premium efficiency fan motors and a simple temperature controller or an added PID loop in the PLC. Because this is an analogue control, the precision is greater than fan cycling (On/Off scheme), thus the outlet fluid temperature can be maintained at  $\pm 0/-2.5$  degrees F relative to the set point. This is a relatively low cost solution as the VFDs are used in lieu of the motor starters for the fans.



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Spraywater Control (not recommended) – The pump should be either off or on at 100% flow rate in order to fully & continuously drench the tube surfaces during operation. Turning the pump off effectively converts the WSAC unit into an inefficient air cooler, which may be desirable when low or zero heat rejection is required. ***Modulating the spraywater flow is not an appropriate means of regulating the amount of heat removed from the process stream. This could lead to tube fouling/scaling that would decrease the efficiency of the cooler and prevent proper performance when operating conditions approached the design point.***

Q: What precautions or other added features are needed for operating the WSAC reliably during the winter?

A: The WSAC is designed for outdoor operation year round. The WSAC is protected from freezing as long as a heat load is present. If one or more of the fans will be turned off for an extended period of time while operating during colder weather, space heaters for the fan motors should be considered. Basin heaters are another accessory which prevents the water in the basin from freezing.

### **WSAC Materials of Construction**

Q: Our facility is very close to the ocean, what kind of fan shaft do you recommend (ex. Stainless Steel, Galvanized Carbon Steel, etc.)?

A: Current technological designs used for closed loop evaporative coolers and cooling towers utilize composite shafts. Stainless Steel shafts are more expensive and have experienced alignment and vibration issues in the past.

Q: Why would you suggest using the PVC material for spray piping rather than Galvanized Carbon Steel?

A: Niagara uses Galvanized Carbon Steel for most of its smaller metal basin units, but for larger, field erected style evaporative coolers PVC spray piping material is used instead of Galvanized Steel. This is because PVC piping is less expensive for larger quantities, is corrosion resistant, will not be affected by sunlight (UV stabilized) and will last longer.



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Q: Concrete is expensive in our area of the world, are there any other options for basin materials?

A: Niagara WSAC units come in a variety of sizes. The smaller, factory built units are made with metal basins. The larger, field-erected units typically use concrete, however, fiberglass reinforced plastics (FRP) is also an option for the walls and plenum. A three (3) ft. high (approximate) "swimming pool" must be laid in concrete to enclose the basin water level. This may be more cost effective in certain instances.

**For further questions, please contact Niagara at 1-800-426-5169**