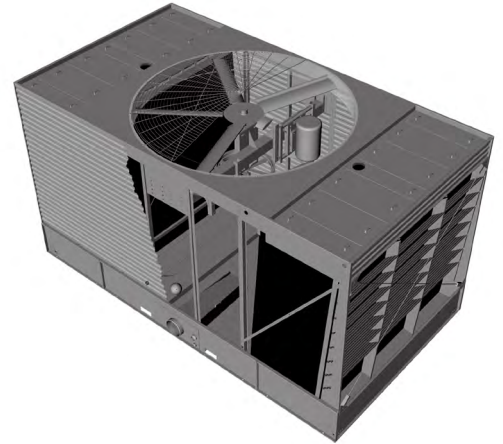




**BALTIMORE  
AIRCOIL COMPANY**



# **Series 3000 Cooling Tower**

## **OPERATION & MAINTENANCE MANUAL**



# ✓ Recommended Maintenance Service<sup>[1]</sup>

Inspect and clean as necessary:	Start-Up	Monthly	Quarterly	Annually	Shutdown
Inspect general condition of the unit <sup>[2]</sup> and check unit for unusual noise or vibration	✓	✓			
Inspect cold and hot water basins	✓		✓		
Flush water distribution system/Inspect spray nozzles	✓		✓		
Drain basin and piping	✓				✓
Inspect air intake louvers/Combined inlet shields	✓	✓			
Check and adjust water level in cold water basin	✓	✓			
Check operation of make-up valve	✓	✓			
Check and adjust bleed rate	✓	✓			
Check optional EASY CONNECT® Piping Arrangement	✓				✓
Inspect unit finish				✓	
Mechanical equipment system:	Start-Up	Monthly	Quarterly	Annually	Shutdown
Check belt condition		✓			
Adjust belt tension <sup>[3]</sup>	✓		✓		
Lubricate fan shaft bearings <sup>[4]</sup>	✓		✓		✓
Lubricate motor base adjusting screw	✓		✓		✓
Check and lubricate optional gear drive or ENDURADRIIVE® Fan System	See "Fan Drive System" on <b>page 13</b> for detailed instructions and schedule.				
Check drive alignment				✓	
Check motor voltage and current	✓		✓		
Clean fan motor exterior	✓		✓		
Check fan motor for proper rotation	✓				
Check general condition of the fan	✓		✓		
Verify fan blade drain holes are not obstructed (hollow blade fans)			✓		
Check fan for uniform pitch			✓		
Check fan for rotation without obstruction	✓		✓		
Verify the fan guard is properly installed	✓			✓	
Verify the operation and function of electric immersion heater and controls, if so equipped			✓		
Check and recoat steel shafts with RUST VETO®	✓		✓		✓
Check optional vibration cutout switch	✓			✓	



**DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service on or near the fans, motors, and drives, or inside the unit without first ensuring that the fans and pump motors are disconnected, locked out, and tagged out.



**NOTES:**

1. Recommended service intervals are the minimum for typical installations. Different environmental conditions may dictate more frequent servicing. Follow all safety and equipment precautions on **pages 2 and 3**.
2. When operating in ambient temperatures below freezing, the unit should be inspected more frequently. Refer to "Cold Weather Operation" on **page 35** for more details.
3. Tension on new belts must be readjusted after the first 24 hours of operation and quarterly, thereafter.
4. Lubricate fan shaft bearings quarterly or every 2,000 hours of operation, whichever occurs first.



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OPERATION & MAINTENANCE » SERIES 3000 COOLING TOWER

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# Safety and Equipment Precautions



## DANGER

- **DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked out, and tagged out.
- **DANGER:** On installations where there are multiple adjacent cells which may be traversed to gain access to another cell, all fan motors must be disconnected, locked out and tagged out, including those on adjacent cells, before performing any service on or near the fans and drive systems, and before traversing adjacent cells. Failure to follow this instruction may result in serious injury or death caused by contact with rotating equipment.
- **DANGER:** If the fan guard is removed or if the fan guard installation is altered for any reason, the fan guard must be reinstalled properly in accordance with the instructions contained in this manual before operating the fan. Failure to follow this instruction may result in serious injury or death caused by contact with rotating equipment.



## WARNING

- **WARNING:** When access to the top of the unit is desired, the purchaser/end-user is cautioned to use appropriate means to comply with applicable safety standards related to working on elevated surfaces.
- **WARNING:** When the fan speed of the unit is to be changed from the factory set speed, including changes achieved by the use of a variable fan speed device, steps must be taken to avoid operation at or near the fan's "critical speed" which could result in fan failure and possible personal injury or damage.
- **WARNING:** The recirculating water system may contain chemicals or biological contaminants, including Legionella, which could be harmful if inhaled or ingested. Personnel exposed directly to the discharge airstream and the associated drift mists, generated during operation of the water distribution system and/or fans, or mists produced by high pressure water jets or compressed air (if used to clean components of the recirculating water system), must wear respiratory protection equipment approved for such use by governmental occupational safety and health authorities.
- **WARNING:** All electrical, mechanical, and rotating machinery are potential hazards, particularly for those not familiar with their design, construction, and operation. Accordingly, use appropriate lockout procedures. Adequate safeguards (including the use of protective enclosures where necessary) should be taken with this equipment both to safeguard the public from injury and to prevent damage to the equipment, its associated system, and the premises.
- **WARNING:** A lockable disconnect switch should be located within sight of the unit for each fan motor associated with this equipment. Before performing any type of service or inspection, make certain that all power has been disconnected, and the switch is locked out in the "OFF" position.
- **WARNING:** Dangerous voltages are present in this equipment. Disconnect the electrical service of the source and follow proper lock out and tag out procedures to de-energize the circuit before servicing or replacing components.
- **WARNING:** To prevent possible contamination of the make-up water supply, install a backflow prevention method in accordance with applicable local and national codes.



## CAUTION

- **CAUTION:** The operation, maintenance, and repair of this equipment shall be undertaken only by personnel authorized and qualified to do so. All such personnel shall be thoroughly familiar with the equipment, the associated system and controls, and the procedures set forth in this manual. Proper care, procedures, and tools must be used in handling, lifting, installing, operating, maintaining, and repairing this equipment to prevent personal injury and/or property damage.
- **CAUTION:** Openings and/or submerged obstructions may exist in the bottom of the cold water basin. Use caution when walking inside this equipment.
- **CAUTION:** Follow exposure control and personal protective equipment requirements as outlined in the MSDS for all recommended lubricant and maintenance materials
- **CAUTION:** BAC does not recommend field application of aftermarket coatings in the cold water basins of products equipped with electric immersion heaters. The coating material may create an increased risk of fire if the heaters remain energized for any reason without sufficient water in the cold water basin.



## NOTICE

- The basin heater is not designed to prevent icing during unit operation.
- The heater control panel temperature/low level control can only be used with the supplied combination temperature/liquid level sensor probe. Please contact your local BAC Representative for replacement parts.
- For the stand alone BAC heater control panel, do not operate the system unattended or for extended periods of time during test mode (resistor across terminals T1 and T2). Operation in water temperatures above 45°F (7.2°C) could damage the unit.
- For heater control panels, do not operate the system unattended or for extended periods of time with terminals G1-G2 jumpered. A low liquid level condition could occur, and the system will not shut off which could result in damage to the heater and unit.
- Ensure the controls for the fan motor are set to allow a maximum of six on-off cycles per hour to prevent motor overload.
- For fan motors controlled with VFDs with a switching frequency of 2.5 kHz, the line lead length cannot exceed 100 feet. If the switching frequency is higher than 2.5 kHz and/or the line lead length exceeds 100 feet, a dV/dT output filter is recommended to protect the motor.
- When reversing the direction of fan rotation, allow the fan to come to a complete stop before restarting the motor.
- Only lubricate the bearings with one of the following compatible water resistant greases on **page 23**.
- Do not use steam or high pressure water to clean PVC eliminators or materials other than steel.
- Never use chloride or chlorine based solvents such as bleach or muriatic (hydrochloric) acid to clean stainless steel. It is important to rinse the surface with warm water and wipe with a dry cloth after cleaning.
- Gear drives should not be used with Wye-Delta (Y- ) motors.
- For installations with 2-speed motors when slowing from high speed, allow a minimum 15-second time delay for the fan to slow down before energizing the low-speed winding.
- For towers with optional gear drives, do not mix synthetic lubricants and mineral oils. Attempt to use only one brand of lubricant at all times. If the brand is changed, completely drain the old oil before filling the gear with new oil.
- Do not use power tools on the whisper quiet fan.

## General Maintenance Information

The services required to maintain a piece of evaporative cooling equipment are primarily a function of the quality of the air and water in the locality of the installation:

- **AIR:** The unit should be located such that unusual quantities of industrial smoke, chemical fumes, salt, or heavy dust do not enter the equipment. Such airborne impurities entering into the equipment and absorbed by the recirculating water, which can form a corrosive solution.
- **WATER:** As water evaporates from the equipment, dissolved solids are left behind, which were originally contained in the make-up water. These dissolved solids may be either alkaline or acidic and as they are concentrated in the circulating water, they can cause scaling or accelerated corrosion.

The extent of impurities in the air and water determines the frequency of most maintenance services and also governs the extent of water treatment which can vary from a simple continuous bleed and biological control to a sophisticated treatment system. Refer to “Water Treatment” on **page 28** and “Biological Control” on **page 31** for more details.

For Dangers, Warnings, and Notices for the ENDURADRIVE® Fan System, refer to **page 13**.

## Warranties

Please refer to the Limitation of Warranties in the submittal packet applicable to and in effect at the time of the sale/purchase of these products. Described in this manual are the recommended services for start-up, operation, and shutdown, and the approximate frequency of each.

# Unit Operation and Storage

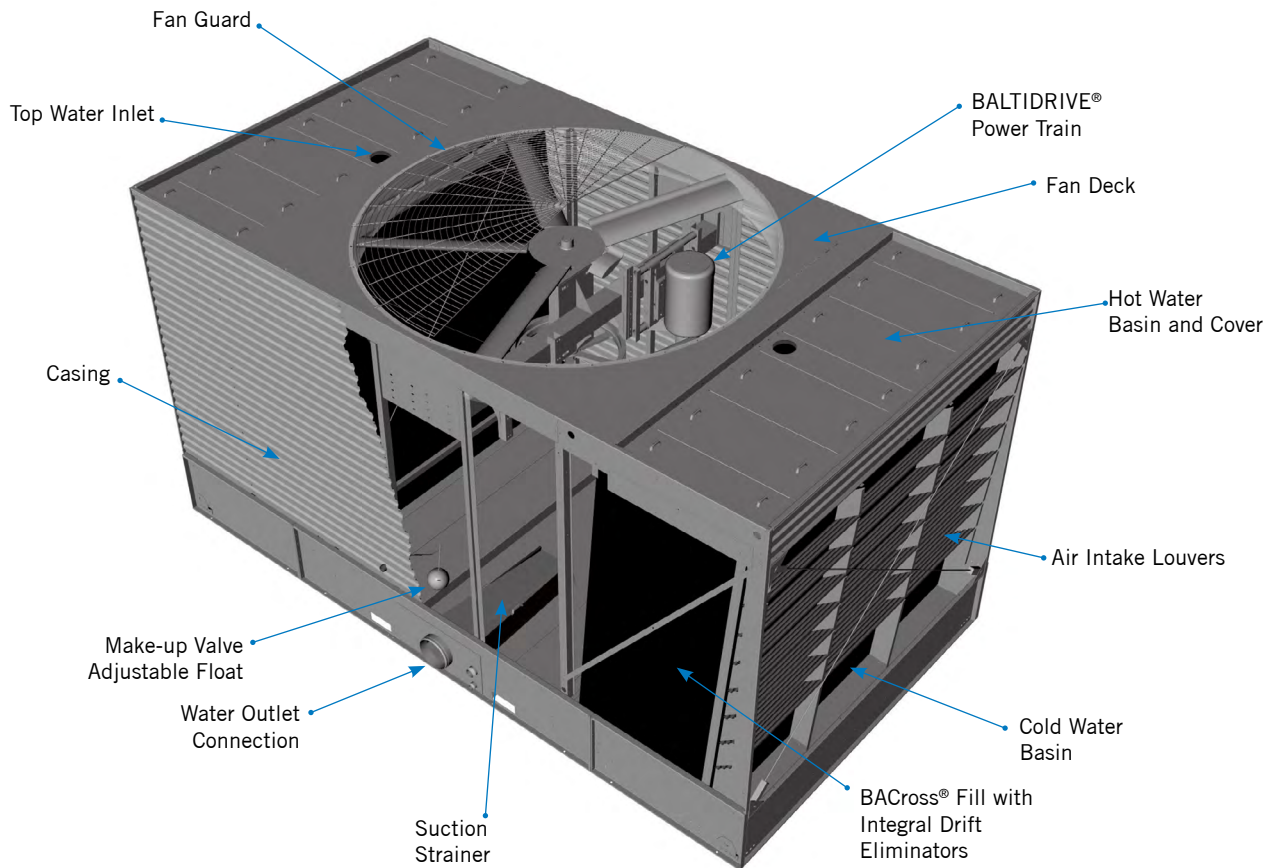


Figure 1. Series 3000 Cooling Tower

**DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked out, and tagged out.



## General

- If the unit is mounted on vibration isolators or isolation rails (by others), refer to the vibration isolation manufacturer's guidelines before loading/unloading weight from the unit.
- Verify the fan and system pump motors are disconnected, locked out, and tagged out.

## Cleaning

- Drain the cold water basin with the strainer in place.
- Open the hot water basin covers and remove any dirt or debris from the hot water basins.
- Clean and inspect the fan deck.
- Remove dirt and debris from the fan guard(s).
- Inspect and clean all spray nozzles.
- Clean and inspect the mechanical components, such as the fan and motor.
- Flush the cold water basin to remove any accumulated dirt and debris.
- Remove, clean, and replace the cold water basin strainer.

## Inspection

- Conduct external inspection of the equipment. Check for leaks, corrosion, and any structural damage.
- Conduct internal inspection of the equipment. Check for anything unusual such as structural or mechanical component damage.
- Inspect piping and connections.
- Thoroughly inspect the fan for any damage.
- Verify proper fan tip clearance. Refer to Fan “Inspection & Maintenance” on **page 10**.
- At seasonal start-up or after prolonged shutdown, check the motor insulation with an insulation tester prior to the motor start-up.
- Check and adjust the belt tension or check gear drive oil levels.
- Check that the float operated make-up valve is operating freely.

## Start-Up

Prior to seasonal start-up, lubricate the motor base adjusting screw (see **Figures 4a and 4b** on **page 12**) and the fan shaft bearings (see **page 20**). At initial start-up, bearings are factory lubricated prior to shipment. However, if the unit has been idle for more than three months, re-lubricate the bearings (see **page 20**). For towers with the optional gear drive system, refer to **page 16**.

- Apply RUST VETO® to steel shafts.
- Fill the cold water basin with fresh water to the overflow level via the make-up valve.
- Set the make-up valve float so the water shuts off at the operating level (see **Table 1, page 9**).
- For units with the optional EASY CONNECT® Piping Arrangement, verify the drain plug is installed.
- Check that the float-operated make-up valve is operating freely. Closely monitor the water level and adjust as necessary during the first 24 hours of operation.
- For the top inlets only, adjust the flow balancing valves to equalize flow to the hot water basin(s). This valve may be provided by others or optionally supplied by BAC.
- Series 3000 Cooling Towers equipped with the optional EASY CONNECT® Piping Arrangement do not require balancing the flow to the hot water basins.
- For multicell arrangements, balance the flow between the cells to obtain even water distribution.



## Unit Operation and Storage

### Start-Up Procedure

- General
- Cleaning
- Inspection
- Start-Up



**NOTICE:** Ensure the controls for the fan motor are set to allow a maximum of six on-off cycles per hour to prevent motor overload.

**NOTICE:** Ensure the controls for the fan motor are set to allow a maximum of six on-off cycles per hour to prevent motor overload.



- Adjust the valve (supplied by others) in the tower bleed line to achieve the desired bleed rate by closing or opening the valve.
- Inspect the nozzles and heat transfer section as described in “Water Distribution System” on **page 22 (Figure 6)**.
- Execute one of the following biocide treatment programs while operating the circulating pump and prior to operating the unit fans:
  - Resume treatment with the biocide that was used prior to shutdown. Operate the pump only while maintaining the maximum recommended biocide residual for a sufficient duration (residual and time will vary with the biocide) as recommended by the water treatment supplier. Start the fan only after this treatment period is completed.
  - Check the pH of the circulating water and, if necessary, adjust it to 7.0 - 7.6 pH. Then, running the pump only, treat the system with sodium hypochlorite to maintain a level of 4 to 5 mg/l (ppm) free chlorine (as Cl<sub>2</sub>) over a six hour period. Test kits for measuring the free residual of chlorine are commercially available. Start the fan only after this treatment period is completed.
- For units with the optional gear drive system, see **page 16** for initial start-up.
- For initial start-up, briefly energize the fan motor(s) and note the direction of rotation. The fan should rotate in the direction indicated by the arrow on the fan cowl.
- Run the fan in manual mode for several minutes to check for any unusual noise or vibrations.
- For the BALTIGUARD™ Fan System, BALTIGUARD PLUS™ Fan System or 2-speed motors: check that the starter incorporates a 15 second time delay when switching from high to low speed.
- Check the operation of the vibration cutout switch (see **page 41**).
- Once the cooling tower is operating, check the current and voltage of all three phases (legs) of the fan motor with a heat load on the tower under warm ambient conditions. The current must not exceed the motor nameplate rating.
- For units with VFDs, see **page 40**.
- For units with the optional Electric Water Level Control, see **page 26**.

**After 24 hours of operation under thermal load, perform the following services:**

- ✓ Check the tower for any unusual noise or vibrations.
- ✓ Check the operating water level in the hot and cold water basins.
- ✓ Adjust the make-up valve if necessary.
- ✓ Check the belt tension and readjust if necessary.
- ✓ Inspect the spray nozzles and heat transfer section.



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## Extended Shutdown

**Perform the following services whenever the unit is shutdown in excess of three days:**

- If the unit is mounted on vibration isolators or isolation rails (by others), refer to the manufacturer’s guidelines before loading/unloading weight from the unit.
- Disconnect, lock-out, and tag-out all fans and pumps.
- Close the shut-off valve in the make-up water line (supplied by others) and drain cold water basin and all exposed water piping. Heat trace and insulate all exposed piping.
- To minimize the risk of biological contamination during shutdown, it is recommended the entire system be drained.
- Clean all debris, such as leaves and dirt, from the interior and exterior of the unit, including the louvers or the optional combined inlet shields.
- Clean and flush the cold water basin with the basin strainer in place.
- Leave the cold water basin drain open so rain and melting snow will drain from the unit.





## Unit Operation and Storage

### Start-Up Procedure

Start-Up

### Extended Shutdown

### Prolonged Outdoor Storage

Storage Preparation

Motor Recommendations

- Clean the basin strainer and re-install.
- Cover the fan discharge to keep out dirt and debris.
- Lubricate the fan shaft bearings, motor base, and motor base adjusting screw.
- Apply RUST VETO® to steel shafts.
- Inspect the protective finish on the unit. Clean and refinish as required. Refer to “Corrosion Protection” on **page 25** for more details.
- Lockout the fan motor starting device in the “OFF” position to ensure personal safety in case of future inspection or service.

## Prolonged Outdoor Storage

### Storage Preparation

- Conduct the “Extended Shutdown” procedure on **page 6** if the unit is installed.
- Ensure the cold water basin is fully drained and the drain is open.
- For storage prior to installation, all components and accessories, which sometimes ship inside the tower and are not a permanent fixture in the basin, should be removed and stored indoors.
- Remove the drain plug from the optional EASY CONNECT® Piping Arrangement. The drain should remain open throughout prolonged storage period. Retain the drain plug for future installation.
- Remove and store fan belts (if supplied) at room temperature. Tag belts appropriately for future identification.
- Apply a weather-resistant lubricant or heavy grease such as Anti-Seize (BAC Part # 160069) to all exposed threaded or flanged connections and adjustable motor base threaded rod.
- Insert desiccant bags into the control panel (if supplied) to absorb moisture. Seal the control panel for storage.
- Spray coat electrical component housings (if supplied) with a suitable protective coating, such as Cosmoline® Weathershed, and individually cover them with plastic taking care to leave openings for free air circulation.
- Inspect the protective finish on the unit. Clean and refinish as required. Refer to “Corrosion Protection” on **page 25** for more details.

### Motor Recommendations

BAC standard motors are designed for storage at ambient temperatures of -20°F to 104°F (-28.9°C to 40°C). Prolonged periods of exposure above or below these specified conditions could degrade components of the motor and cause malfunction or premature failure.

- Motors should be removed and stored inside whenever possible. When indoor storage is not possible the motors must be covered with a tarpaulin. Do not use plastic or plastic film. This cover should extend below the motor and be secured; however, it should not tightly wrap the motor. This will allow the captive air space to breathe, minimizing formation of condensation.
- Care must also be taken to protect the motor from flooding or from harmful chemical vapors.



**NOTICE:** Covering the unit with a clear plastic tarpaulin during storage can trap heat inside the unit and cause damage to the PVC components. If units must be covered during storage, an opaque, reflective tarp should be used.



**DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked out, and tagged out.

- The storage area should be free from ambient vibration. Excessive vibration can cause bearing damage.
- Precautions should be taken to prevent rodents, snakes, birds, or other small animals from nesting inside the motors. In areas where they are prevalent, precautions must also be taken to prevent insects from gaining access to the interior of the motor.
- If not stored indoors in a controlled environment, some form of heating must be utilized to prevent condensation from accumulating in the motor. This heating should maintain the winding temperature at a minimum of 9°F (-12.8°C) above the ambient temperature of the surrounding environment, keeping it from dropping below the dew point where condensation could form inside the motor. If space heaters are supplied, they should be energized. Request the required voltage and transformer capacity from your local BAC Representative. A third option is to use an auxiliary heat source and keep the winding warm by either convection or blowing warm air into the motor.
- Rotate the motor shaft monthly to redistribute bearing grease.

## Maintenance Requirements

- Rotate all fans and motor shafts monthly by hand. Hand-turning will ensure that the shafts and bearings are free and will redistribute grease within the bearings. Keep hands away from pinch points such as bolts and sheaves.
- Inspect the cold water basin monthly to ensure that the drain is open and remove any leaves or debris that may have accumulated in the cold water basin.
- Inspect axial fans prior to start-up and at least once annually to ensure that the blades are tight and that there is no obvious corrosion between the hub and the fan blade.
- Inspect the rust preventative coating on all motor external machined surfaces including shaft extensions monthly. If necessary, re-coat the surfaces with RUST VETO®.

## Start-Up Preparation After Prolonged Storage

Keep in mind that start-up procedures after long periods of storage are just as important as pre-shutdown procedures.

- Motors should be thoroughly inspected and cleaned and restored to pre-storage condition.
- Inspect the axial fan prior to start-up to ensure that the blades are tight and that there is no obvious corrosion between the hub and the fan blades. Do not energize the fan if there is obvious corrosion of fan components. Loose fan blades could result in fan failure and possible injury or damage.
- Reinstall all fan belts, motors, door gaskets, and drain plugs (as applicable), and remove all protective coverings.
- For units stored prior to installation, conduct rigging procedures as directed in the unit's *Rigging and Assembly Instructions*, available on [www.BaltimoreAircoil.com](http://www.BaltimoreAircoil.com) or by contacting your local BAC Representative.
- Perform an insulation test of motor windings to ensure satisfactory insulation resistance.
- Conduct full start-up procedure as stated in the "Start-Up Procedure" on **page 4**. Be especially thorough for cleaning and inspection prior to start-up.
- For units with the optional gear drive system, the gear box must be fully drained, then refilled with new oil at or near the middle of the oil level sight gauge to prevent damage. Then, follow the steps in "Initial Start-up" on **page 16**.

**DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked



# Detailed Component Maintenance Procedures



## Cold Water Basin

As water circulating through the cooling tower is cooled, it collects in the cold water basin and passes through the suction strainer into the system. The cold water basin is constructed from one of the following materials of construction and the following maintenance applies to all basin materials of construction.

- Galvanized steel
- TriArmor® Corrosion Protection System
- Welded Type 304 stainless steel

### Water Levels

Model Number	At Overflow Level (in.)	At Operating Level (in.) <sup>[2]</sup>	Model Number	At Overflow Level (in.)	At Operating Level (in.) <sup>[2]</sup>
S3E/XES3E-8518-05x, 8518-06x	14 1/8	8 3/4	S3E/XES3E-1222-12x	21 5/8	9 3/4
S3E/XES3E-8518-07x	17 1/2	8 3/4	S3E/XES3E-1222-13x, 1212-14x	22 <sup>[1]</sup>	9 3/4
S3E/XES3E-1020-06x	14 3/4	8 3/4	S3E/XES3E-1424-07x	16 <sup>[1]</sup>	9 3/4
S3E/XES3E-1020-07x	15 1/2	8 3/4	S3E/XES3E-1424-12x	19 5/8 <sup>[1]</sup>	9 3/4
S3E/XES3E-1222-06x	14 5/8	8 3/4	S3E/XES3E-1424-13x	20 1/4 <sup>[1]</sup>	9 3/4
S3E/XES3E-1222-07x	15 1/4	8 3/4	S3E/XES3E-1424-14x	21 <sup>[1]</sup>	9 3/4
S3E/XES3E-1222-10x	20 1/8	9 3/4			

Table 1. Cold Water Basin Water Levels (Measured From Inside the Cold Water Basin)

- The operating water level in the cold water basin will vary with system thermal load (evaporation rate), the bleed rate employed, and the make-up water supply pressure.
- The make-up valve controls the operating level, which should be maintained at the levels shown in **Table 1**.
- Check the operating water level monthly, and readjust the float when necessary to maintain the recommended operating level.
- Consult “Water Level Control” on **page 25** for information on how to set and maintain the basin operating level.



**NOTES:**

1. The following materials of construction combinations have a basin overflow height of 18 1/2":
  - TriArmor® Corrosion Protection System or stainless steel cold water basin with either galvanized steel or thermosetting hybrid polymer frame
  - EVERTOUGH™ Construction
2. These are the standard operating levels. If the connection size is custom, contact your local BAC representative.

**CAUTION:** Openings and/or submerged obstructions may exist in the bottom of the cold water basin. Use caution when walking inside this equipment.



## Inspection & Maintenance

- Inspect the cold water basin regularly. Remove trash or debris that may have accumulated in the basin or on the strainer.
- Quarterly, or more often if necessary, drain, clean, and flush the entire cold water basin with fresh water. This will remove the sediment, which can collect in the basin during operation. If not removed, sediment can become corrosive and cause deterioration of the protective finish of metallic basins.
  - When flushing the basin, leave the strainer in place to prevent debris from entering the system.
  - Remove the strainer after the basin has been flushed.
  - Clean and replace the strainer before refilling the basin with fresh water.
- Adjust the float to maintain the design operating level. See **Table 1** on **page 9**.

**DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked out, and tagged out.



The Series 3000 Cooling Tower uses an axial fan. Thoroughly inspect the fan for damaged or deteriorated fan blades and replace the fan as required.

**DANGER:** If the fan guard is removed or if the fan guard installation is altered for any reason, the fan guard must be reinstalled properly in accordance with the instructions on page 20 before operating the fan. Failure to follow this instruction may result in serious injury or death caused by



## Inspection & Maintenance

- If the unit is already in operation, while the fan is running, check for any unusual noise or vibration.
- With the fan off and the motor disconnected, locked out, and tagged out, check the general condition of the fan:
  - Inspect for any loose or missing bolts in the fan shaft bushing, the fan hub, and the fan shaft bearing(s).
  - Check the fan blades for looseness, first by twisting the blade by hand, and then by moving the blade tip up and down. There should be no play or slippage.
  - Inspect each blade for excessive scale build-up that could cause vibration.
  - Check each blade for any cracks. If cracks are found, the fan motor should be locked out until the fan is replaced. Contact your local BAC Representative for assistance.
- **For the optional whisper quiet fan only:**

Model Number	Fan Dia.	Allen Head Bolt Type	Tightening Torque
S3E/XES3E-1020-x	9'	12 mm	50 ft-lbs
S3E/XES3E-1424-12x, 1424-13x, 1424-14x	11' to 13'	16 mm	90 ft-lbs

**Table 2.** Whisper Quiet Fan Tightening Torque

**NOTICE:** Do not use power tools on the whisper quiet fan.



- During first week of operation, the blades shall be inspected at least once to ensure that all nuts are tightened to the torque value listed in **Table 2**.
- After the first week of operation, the blades shall be inspected at regular intervals, a minimum of once every month, for deposits and damage. To remove deposits, use steel wool as an abrasive along with a mild detergent or very mild form of solvent. Lye must not be used because it attacks aluminum readily.
- At regular intervals, the hub shall be inspected for damage, including bending and twisting.



## Detailed Component Maintenance Procedures

### Cold Water Basin

Inspection & Maintenance

### Fan

Inspection & Maintenance

### Fan Drive System

BALTIDRIVE® Power Train/  
BALTIGUARD™ and  
BALTIGUARD PLUS™ Fan System



**NOTICE:** Ensure the controls for the fan motor are set to allow a maximum of six on-off cycles per hour to prevent motor overload.

- To ensure optimal functioning and operational safety of the impeller, it is necessary to at least once a year check the tightening torque of the bolt connections (refer to **Table 2**) and replace corroded bolts and nuts.
- With the fan off and the motor disconnected, locked out, and tagged out, check the general condition of the fan:
  - **Tip Clearance:** Check the clearance between the tip of the blade and the fan cowl. The clearance should be sufficient to prevent the fan blades from contacting the fan cowl during operation. Contact your local BAC Representative if there are any concerns.
  - **Drain Holes:** On hollow blades, the drain hole in the blade tip should be unobstructed. Tip: Use a piece of wire to clear the drain hole.
  - **Blade Pitch:** Check to ensure that the blades are all at the same pitch. If uncertain, measure the pitch with an inclinometer. All blades should be within 1/2° of each other.
  - **Rotation:** Turn the fan by hand to ensure that it moves freely with no rough spots, binding, or other malfunctions that could cause vibration or fan motor overload. While rotating the fan, check the blade tracking. All blades should track within a 1" band at any single point around the cowl.
  - **Direction of Rotation:** On initial start-up, or if the fan motor has been rewired, briefly energize the fan motor and note the direction of fan rotation. It should rotate in the direction indicated by the arrow on the fan cowl.
  - **Operation:** On initial start-up, run the fan in the manual position for several minutes, and check for any unusual noises or vibration.

## Fan Drive System

### BALTIDRIVE® Power Train/BALTIGUARD™ and BALTIGUARD PLUS™ Fan System

The BALTIDRIVE® Power Train consists of a solid-backed, multi-groove, neoprene/polyester belt rated for cooling tower service, and corrosion-resistant sheaves. These components provide high reliability with low maintenance requirements.

The BALTIGUARD™ Fan System consists of two standard single-speed fan motors and drive assemblies. One drive assembly is sized for full speed and load, and the other is sized for approximately 2/3 speed and consumes only 1/3 the design horsepower.

The BALTIGUARD PLUS™ Fan System builds on the advantages of the BALTIGUARD™ Fan System by adding a VFD to one of the motors.

### Inspection & Maintenance

These drives require a periodic check of the belt condition and, when necessary, tension adjustment. The recommended service intervals are as follows:

- **Initial Start-Up:** The drive has been tensioned and aligned at the factory; however, prior to initial startup, check belt tension.
- **Seasonal Start-Up:** Readjust the belt tension (if required).
- **Operation:** After the first 24 hours of operation, readjust the belt tension on a new unit start-up or installation of a new belt. Thereafter, check the belt condition monthly, and adjust tension as necessary. Readjust tension at least once every three months.



Figure 2. BALTIGUARD™ Fan System



**DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked out, and tagged out.

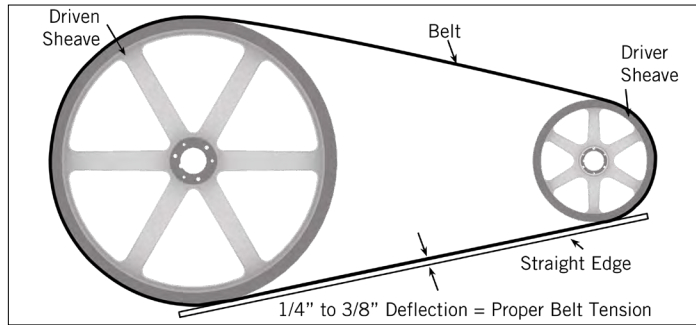
**NOTE:** If belts are properly tensioned, there should be no “chirp” or “squeal” when the fan motor is started.

**NOTICE:** Ensure the controls for the fan motor are set to allow a maximum of six on-off cycles per hour to prevent motor overload.

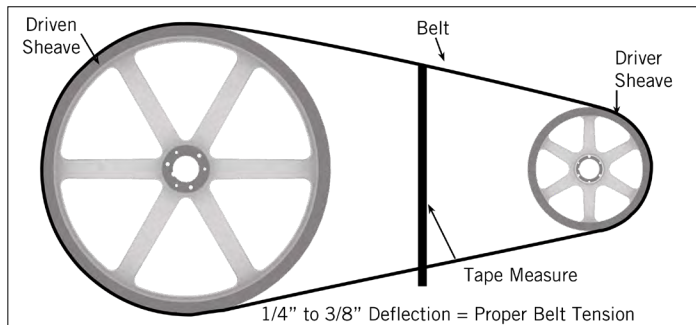


• **Belt tension check:**

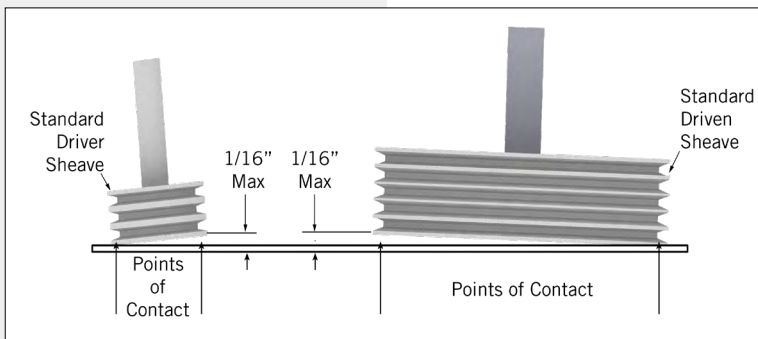
- Place a straight edge along the belt from sheave to sheave as shown in **Figure 3a**, or use a tape measure as shown in **Figure 3b** to measure belt deflection.
- Apply a moderate force by hand (approximately 40 lbs/275 kPa) evenly across the width of the belt in the center of the span between the sheaves.
- There is adequate belt tension if the belt deflects between 1/4” and 3/8” as shown in **Figures 3a** and **3b**.



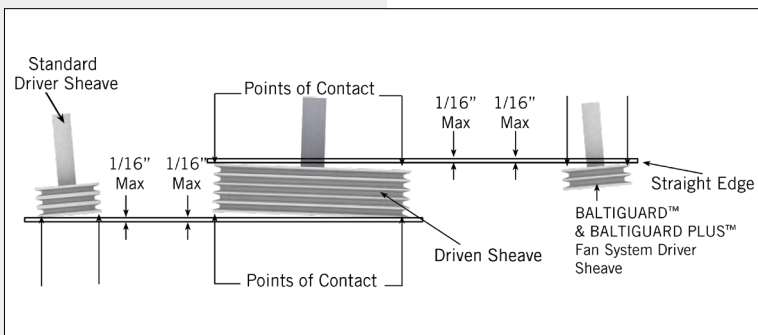
**Figure 3a.** Belt Tension with a Straight Edge



**Figure 3b.** Belt Tension with a Tape Measure



**Figure 4a.** Standard Drive Alignment



**Figure 4b.** BALTI GUARD™/BALTI GUARD PLUS™ Fan System Drive Alignment

• **Belt tension adjustment (if required):**

- Loosen the lock nut on the motor base adjusting screw.
- Turn the motor base adjusting screw clockwise to tension the belt or counterclockwise to relieve belt tension. During adjustment of the belt tension, rotate the drives several times by hand to evenly distribute the tension throughout the belt.
- When the belt is properly tensioned, retighten the locking nut on the motor base adjusting screw.

• **Drive alignment check and adjustment:**

- Check the drive alignment annually to ensure maximum belt life.
- Place a straight edge across the driver and the driven sheaves as shown in **Figure 4a** for standard drives and in **Figure 4b** for the BALTI GUARD™ Fan System or the BALTI GUARD PLUS™ Fan System.
- The straight edge should contact all four points as shown in **Figure 4a** indicating that the drives are properly aligned.
- There should be no more than 1/16” deviation from the four points of contact.
- If realignment is required loosen the motor sheave and align it with the fan sheave. Allow 1/4” for draw-up as the bushing screws are tightened.

## Optional ENDURADRI<sup>®</sup> Fan System

The ENDURADRI<sup>®</sup> Fan System is an option for select Series 3000 Cooling Towers and it is standard on S3E-1424-14U and S3E-1424-14W models. The ENDURADRI<sup>®</sup> Fan System includes a direct drive motor and variable frequency drive (VFD) designed specifically for the motor.



## Detailed Component Maintenance Procedures

### Fan Drive System

BALTDRI<sup>®</sup> Power Train/  
BALTI<sup>™</sup>GUARD and  
BALTI<sup>™</sup>GUARD PLUS Fan  
System

Optional ENDURADRI<sup>®</sup>  
Fan System



### DANGER FOR THE OPTIONAL ENDURADRI<sup>®</sup> FAN SYSTEM

- **DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked out, and tagged out.



### WARNING FOR THE OPTIONAL ENDURADRI<sup>®</sup> FAN SYSTEM

- **WARNING:** Do not disassemble the motor, because it contains strong permanent magnets that can cause severe personal injury or death.
- **WARNING:** ENDURADRI<sup>®</sup> Fan System motors can induce voltage and current in the motor leads by rotating the motor shaft, even when the motor is completely disconnected from the power source. Electrical shock can cause severe personal injury or death. Therefore, mechanically lock or tie down the fan until all wiring has been completed and before servicing the drive system, or when performing any motor maintenance procedure. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.
- **WARNING:** Pacemaker danger – Magnetic and electromagnetic fields in the vicinity of current carrying conductors and ENDURADRI<sup>®</sup> Fan System motors can result in a serious health hazard to persons with cardiac pacemakers, metal implants, and hearing aids. To avoid risk, stay away from the area surrounding a ENDURADRI<sup>®</sup> Fan System motor.
- **WARNING:** The variable frequency drive may apply hazardous voltages to the motor leads after power to the controller has been turned off. Verify that the controller is incapable of delivering hazardous voltages and that the voltage at the motor leads is zero before proceeding. Failure to comply with this warning may result in severe personal injury or death.
- **WARNING:** The surfaces of motor enclosures may reach temperatures that are high enough to cause discomfort or injury to personnel coming into contact with them. Protection should be used to prevent accidental contact with hot surfaces. Failure to observe this precaution could result in personal injury.



### NOTICES FOR THE OPTIONAL ENDURADRI<sup>®</sup> FAN SYSTEM

- VFD must be powered on at all times so that moisture can be removed from motor automatically.
- Do not bypass VFD. The motor can only be operated by VFD, and bypassing the VFD by wiring the motor directly across-the-line will result in motor failure.
- Incorrect motor rotation direction for extended periods can cause equipment damage. Be sure to verify motor rotation direction before operating the unit. When reversing the direction of rotation, allow the fan to come to a complete stop before restarting the motor. Fan reversal should be used only after the other methods of fan control fail. If utilized, the fans should be run in reverse for no longer than 20 minutes at no more than 50% speed, and the cooling tower should be observed during this time. Before returning to normal operation, visually inspect the fan blades for ice formation.
- Use only a shielded motor power cable with a complete circumferential braided or copper film/tape ground jacket around the power leads. This ground should be secured to the motor frame from within the motor terminal box and must return without interruption to the drive ground.
- To prevent equipment damage, be sure that the electrical service is not capable of delivering more than the maximum motor rated amps listed on the rating plate.
- To prevent equipment damage, do not exceed the RPM listed on the motor nameplate.
- If a HI POT test (High Potential Insulation test) must be performed, follow the precautions and procedure in NEMA MG1 and MG2 standards to avoid equipment damage.

## Initial Start-Up

### Motor

- Be sure that all power to motor is off, follow the required lockout/tagout procedure, and mechanically secure the fan to prevent rotation.
- Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity.
- Install the motor conduit box cover and all covers and panels that were removed during installation.
- Remove the mechanical lock or tie down from the fan to allow the fan to turn freely.
- Rotate the fan by hand to be sure there are no obstructions to free rotation. Ensure that no contact is made with electrical connections while rotating the fan.
- A motor that has been in storage for some time should be tested for moisture (dielectric withstand insulation test) and relubricated (regreasable type) prior to being put into service.
- During operation, observe motor performance. It should run smoothly with little noise. The bearings should not overheat and should reach a normal operating temperature. Any undue noise, overheating, or erratic performance should be investigated and corrective action taken immediately to prevent serious damage. All ENDURADRIVE® Fan System motors are lubricated before shipment and will operate for a long period before regreasing is required. The period will vary depending on environmental and service conditions. Refer to Maintenance section of this manual for regreasing intervals.

### Variable Frequency Drive (VFD)

- The ENDURADRIVE® Fan System includes a VFD for each motor, which is required to operate the motor, and only this VFD may be used to operate the motor. This VFD has been designed and programmed for use with this fan system and has been preprogrammed with parameters specific to your cooling tower.
- Startup must be performed by a service provider that is authorized to startup the ENDURADRIVE® Fan System motor and VFD; contact your sales representative for details regarding startup. For technical details about the drive, see the ENDURADRIVE® Fan System ACS880 Start Up Guide.
- The motor can be controlled by sending the VFD either a 4-20mA (default) or a 0-10V (optional) signal. See the submittal drawing for wiring details and dip switch settings.
- The ENDURADRIVE® Fan System may be operated at any speed below the nameplate RPM; there is no required minimum operating speed.
- The VFD must remain powered at all times, even when the motor is not operating. When the run enable (DI1) opens, a trickle current protects the motor from moisture ingress. Refer to the ENDURADRIVE® Fan System ACS880 Start Up Guide for set up and wattage information.
- An optional vibration cutout switch should be wired to the VFD as shown in the submittal. The vibration cutout switch is part of that safety circuit and can be wired in series with other safety measures. See submittal drawings for additional information. Before wiring the vibration cutout switch to the VFD, remove the appropriate factory installed jumper per the submittal drawing.
- All VFDs include Modbus® communication protocol as the standard communication method with your building automation system. BACnet communication protocol is optional using a gateway adapter that includes BACnet MS/TP and BACnet/IP. Depending on the NEMA VFD enclosure rating, the gateway will be field-installed or factory-installed. See wiring details in your submittal, and address details can be found in the ENDURADRIVE® Fan System ACS880 Start Up Guide. For additional protocols, contact your local BAC Sales Representative.



## Inspection & Maintenance

- Inspect the motor at regular intervals, approximately every 500 hours of operation or every 3 months, whichever occurs first.
- The following steps should be performed at each inspection:
  - Turn off the fan motor, and follow the required lockout/tagout procedure.
  - Check that the motor is clean. Check that the exterior fins of the motor are free of dirt, oil, grease, etc. If the motor is not properly ventilated, overheating can occur and cause early motor failure.
  - Perform a dielectric withstand insulation test periodically to ensure that the integrity of the winding insulation has been maintained. Record the readings. Immediately investigate any significant decrease in insulation resistance.
  - Check all electrical connections to be sure that they are tight.

## Relubrication & Bearings

- Bearing grease will lose its lubricating ability over time, not suddenly.
- The lubricating ability of a grease (over time) depends primarily on the type of grease, the size of the bearing, the speed at which the bearing operates and the severity of the operating conditions.
- Good results can be obtained if the following recommendations are followed in your maintenance program.

## Lubrication Procedure

- Relubrication is recommended with the shaft stationary and a warm motor.
- Wipe all dirt from the outside of the grease fills and drains.
- Locate the grease inlet at the top of the bearing hub, clean the area and replace the 1/8" pipe plug with a grease fitting if the motor is not equipped with grease fitting.
- Remove grease drain plug located opposite the grease inlet.
- Using a manual grease gun, pump in the recommended grease in the amount shown in **Table 3**. This amount of grease will provide an ample supply of lubricant between lubrication intervals. Use only clean, fresh grease from clean containers and handle so as to keep it clean. In general, mixing of greases is not recommended. If an incompatible grease is used, the lube system must be repacked completely with the new grease.

Motor Frame Size	Moblith Grease Type	Vol. in Cubic in3 (cm3)	Weight oz (g)	Relubrication Interval (Months)
FL2554, FL2562, FL2570, FL2578	SCH220	1 (16)	0.5 (14)	12
FL2873, FL2882, FL2890, FL2898	SCH460	1.5 (26)	0.75 (21)	12
FL3203, FL3213	SCH460	2 (33)	1.0 (28)	12
FL3698, FL3614	SCH460	2.5 (41)	1.25 (35)	12
FL4022, FL4034, FL4046, FL4058	SCH460	2.5 (41)	1.25 (35)	12

Table 3. Type of Grease, Relubrication Amount, and Interval

- Wipe away any excess grease at the grease drain or relief and replace drain plugs.
- Follow the relubrication interval given in **Table 3** (or sooner) unless otherwise specified on the motor lubrication nameplate.
- Lubrication interval is based upon maximum ambient temperature of 40°C and a minimum air flow of 750ft/min over the motor.
- Motors are shipped from the factory with full grease cavities and ready for operation.



### Fan Drive System

Optional ENDURADRIVE®  
Fan System

## Optional Gear Drive System

### Initial Start-Up

- If the unit is equipped with an extended lubrication line option or external sight glass, make sure the ball valve located at the gear box is open prior to start-up.
- BAC ships all gear drives filled with oil. The initial oil level should be at or near the middle of the oil level sight gauge.
- Internally mounted gear drives are factory installed, aligned, and tightened. Double check all gear drive fasteners after the unit has been installed.
- On units with externally mounted motors, install and align the motor and drive shaft in accordance with BAC's installation instructions. Recheck the alignment and all external fasteners after two weeks of operation.
- On installations with variable frequency drives, do not operate the standard gear drives below 450 RPM motor speed (gear input speed). For speeds less than 450 RPM, a low speed option gear drive must be supplied.
- Prior to the start-up, check all fittings on the gear drive to ensure that there are no visible leaks. Refer to **Figure 5** for locations of the gear drive fittings.

**NOTICE:** Gear drives should not be used with Wye-Delta (Y- $\Delta$ ) motors.

**NOTE:** Continued operation at a speed which resonates with the gear drive system may result in torsional vibrations which can damage system components. The most common indicator of torsional vibration is an unusual rumbling or grinding noise from the gear drive at a narrow speed range. The noise will decrease to normal levels when the speed is increased or decreased away from the offending speed range. This noise is not indicative of a defect, but results when the vibratory torque exceeds the drive torque, causing the gear teeth to separate and clash together very rapidly. On variable frequency applications, avoid operation near this resonance speed by locking out the resonance speed range.

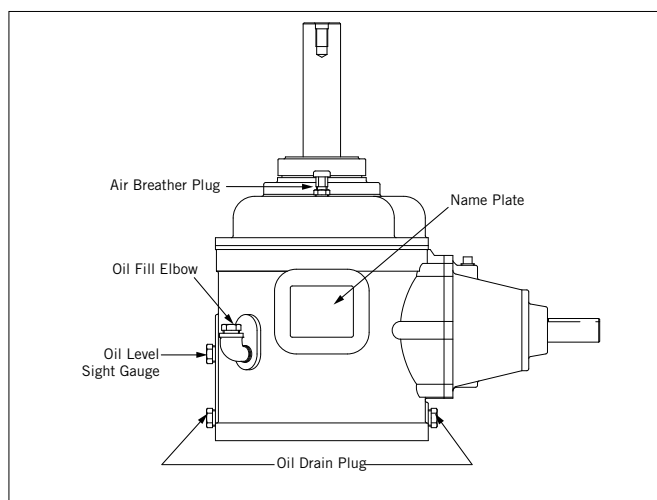


Figure 5. Gear Drive

### Change Interval

- **Initial oil change:** Replace the original oil after 500 hours or four weeks of operation, whichever comes first.
- After the initial oil change, change the oil every 2,500 hours or six months, whichever comes first.
- Drain the oil at operating temperature through the drain plug.
- Refill the gear drive through the oil fill elbow with the recommended type and amount of lubricant (**Table 4, page 18**). Refer to **Figure 5** for locations of these components.

### Inspection & Maintenance

- Maintain the oil level at or near the middle of the oil level sight gauge. The oil level should always be visible in the sight gauge window when the unit is not operating/energized, and the oil is at ambient temperature.
- Check oil level weekly with the unit idle. On units supplied with an external sight gauge, check the oil level of the external sight gauge and the sight gauge on the gear drive to ensure that the proper amount of oil is in the gear drive.
- Add oil through the oil fill elbow if level is below the oil level sight gauge.
- The standard oil provided is mineral oil. Synthetic lubricants are also available as an option (see Fan Drive System "Lubrication" on **Page 18**).



## Detailed Component Maintenance Procedures

- Refer to **Table 4 on page 18** for normal operating oil capacity of each gear drive.
- Refer to **Table 5 on page 19** or the gear drive nameplate for specific gear model number for each unit.
- Quarterly check to ensure proper alignment of all system components.
- Check to ensure that all bolts and external fasteners are tight.
- BAC recommends daily visual inspections and observation for oil leaks and unusual noises and vibrations. If any of these occur, shutdown the unit until the cause is found and corrected.
- If equipped with an external oil line and site gauge, check weekly to make sure the breather hole at the top of the sight gauge is open.

### Routine Maintenance During Operation

- Periodically recheck the alignment and tighten external fasteners as necessary. No special break-in procedures are required.
- Excessive noise or vibration at initial operation is an indication of one or more of the following:
  - Misalignment
  - Imbalance of the fan or other rotating parts
  - Improperly adjusted fan blades
  - Operation at the mechanical equipment resonant frequency
- For gears equipped with the low speed option, operate the fan motor at full speed for at least five minutes weekly to supply oil to the upper bearing reservoir inside the gear casing.
- During periods of inactivity, the lubricant does not constantly lubricate the internal parts of the gear drive, leaving the gear drive susceptible to corrosion. Therefore, the following special precautions are necessary during periods of inactivity:
  - For best results, let the gear drive cool for approximately 4 hours after shutdown.
  - Start the fan and let it run for approximately 5 minutes. This will coat the internal parts of the drive with cool oil.
  - Thereafter, run the fan for 5 minutes once a week, throughout the shutdown period to maintain the oil film on the internal parts of the gear drive.
- Clean the outside of the gear drive at least quarterly.

### Prolonged Shutdown

Follow the procedures below when a gear drive will not be used for a prolonged period of time, including seasonal shutdown.

- Drain all of the old oil from the gear drive and properly discard.
- Re-install drain plug.
- Remove the air breather from the gear drive.
- Completely fill the gear drive through the air breather port with a recommended lubricant listed on **page 18**. Once the gear is filled, do not use the fan motor to rotate the gear as pressure will build up in the gear box and cause damage.
- After completely filling the gear with oil, plug the previously removed air breather port, and all remaining open ports. Use steel plugs to plug the openings, and store the air breather so that you can reuse it when the gear drive is put back in operation.
- Securely attach a “warning” tag to the gear box and motor starter stating that it has been “overfilled” to remind start-up personnel that they need to drain the gear oil back to the proper level before using.
- To establish a moisture barrier, cover the drive with a tarpaulin or other protective cover.

### Fan Drive System

Optional Gear Drive System



**NOTICE:** If noise or vibration persists, shut the unit down and correct the cause before continuing operation.



**NOTICE:** For installations with 2-speed motors when slowing from high speed, allow a minimum 15-second time delay for the fan to slow down before energizing the low-speed winding.



**NOTICE:** When reversing the direction of rotation, allow the fan to come to a complete stop before restarting the motor.



**NOTICE:** Upon start-up, the gear box must be drained back to the proper level before operation to prevent damage. The fan motor should be locked and tagged out in order to prevent operation until the oil level is returned to normal.

- For start-up after prolonged shutdown, the gear box must be fully drained, then refilled with new oil at or near the middle of the oil level sight gauge to prevent damage. Re-install the air breather which was removed prior to the prolonged shutdown. Then, follow the steps in “Initial Start-up” on **page 16**.

### Lubrication

- Use only rust and oxidation inhibited gear oils in accordance with AGMA (American Gear Manufacturer’s Association), Standard 9005-E02.
- The ambient temperature at the gear drive is 20°F to 120°F (-7°C to 49°C) for mineral oils and -20°F to 150°F (-29°C to 66°C) for synthetic lubricants.
- The AGMA lubricant number is 5 for mineral oils and 5S for synthetic lubricants.
- The ISO grade is 220 for both mineral oils and synthetic lubricants.
- Do not use gear oils containing extreme pressure (EP) additives.
- **Recommended mineral oils:**
  - Atlantic Richfield – Duro 220
  - Chevron Oil – Rando HD 220
  - Cities Service Oil – Citgo Pacemaker 220
  - Conoco – Hydroclear Multipurpose R&O Oil 220
  - Exxon – Teresstic 220
  - Gulf Oil – Harmony 220
  - Mobil Oil – DTE Oil BB
  - Pennzoil – Pennzbell TO 220
  - Philips Petroleum – Magnus 220
  - Shell Oil – Morlina SD 220
  - Sun Oil – Sunvis 9220
  - Texaco – Regal 220 R&O, Code 1531
  - Total – Carter 220
- **Recommended synthetic lubricants:**
  - Chevron Oil – Clarity 220 Synthetic
  - Conoco – Syncon 220 R&O Oil
  - Mobil Oil – SHC 630
- When the ambient temperature exceeds 180°F (82°C) or the gear drive is started at an ambient temperature less than 20°F (-7°C), a synthetic lubricant is recommended. When mineral oils are used in operation at ambient temperature less than 20°F (-7°C) lube oil heaters are required. Each unit has provisions for an internal oil reservoir heater. Heaters and synthetic oil are extra cost accessories and can be ordered with new units or may be ordered and installed in existing units.
- The vertical and horizontal shafts are equipped with grease lubricated dual seals. Relubrication is not required.

**NOTE:** List of brand names is for identification only and are not exclusive recommendations.

**NOTICE:** Do not mix synthetic lubricants and mineral oils. Attempt to use only one brand of lubricant at all times. If the brand is changed, completely drain the old oil before filling the gear with new oil.

**NOTE:** Certain gear drive components might be incompatible with the various base stocks used to make synthetic lubricants. Contact your local BAC Representative prior to using any synthetic lubricant not listed.

**NOTE:** For units with the extended lubrication line option, additional oil beyond the capacities listed in **Table 4** will be required to fill the oil line.

Gear Model	Gallons	Liters
65	0.5	2
85	1	4
110	2	8
135	3	11
155	5.5	21
175	5.5	21

**Table 4.** Normal Operating Oil Capacity

S3E and XES3E Truncated Model Number	Gear Model for Standard Fan	Gear Model for Low Sound Fan	S3E and XES3E Truncated Model Number	Gear Model for Standard Fan	Gear Model for Low Sound Fan
8518-05J	65	85	1222-12M	110	135
8518-05K	65	85	1222-12N	110	135
8518-05L	65	85	1222-12O	110	135
8518-05M	85	85	1222-12P	110	135
8518-06H	85	-	1222-12Q	110	135
8518-06J	65	85	1222-12R	110	155
8518-06K	65	85	1222-12S	135	155
8518-06L	65	85	1222-13M	110	135
8518-06M	85	85	1222-13N	110	135
8518-06N	85	85	1222-13O	110	135
8518-06O	85	85	1222-13P	110	135
8518-07H	85	-	1222-13Q	110	135
8518-07J	65	85	1222-13R	110	155
8518-07K	65	85	1222-13S	135	155
8518-07L	65	85	1222-14M	110	135
8518-07M	85	85	1222-14N	110	135
8518-07N	85	85	1222-14O	110	135
8518-07O	85	85	1222-14P	110	135
8518-07P	110	110	1222-14Q	110	135
1020-06J	85	85	1222-14R	110	155
1020-06K	85	110	1222-14S	135	155
1020-06L	85	85	1222-14T	155	175
1020-06M	85	110	1424-07M	110	135
1020-06N	85	110	1424-07N	110	135
1020-06O	85	110	1424-07O	110	135
1020-07J	85	85	1424-07P	110	135
1020-07K	85	110	1424-07Q	110	135
1020-07L	85	85	1424-07R	110	155
1020-07M	85	110	1424-12P	110	175
1020-07N	85	110	1424-12Q	135	175
1020-07O	85	110	1424-12R	135	175
1020-07P	110	110	1424-12S	155	175
1222-06K	85	85	1424-12T	175	175
1222-06L	85	135	1424-13P	110	175
1222-06M	85	110	1424-13Q	135	175
1222-06N	85	110	1424-13R	135	175
1222-06O	110	110	1424-13S	155	175
1222-07K	85	85	1424-13T	175	175
1222-07L	85	135	1424-14P	110	175
1222-07M	85	110	1424-14Q	135	175
1222-07N	85	110	1424-14R	135	175
1222-07O	110	110	1424-14S	155	175
1222-07P	110	135	1424-14T	175	175
1222-07Q	110	135			
1222-07R	110	135			
1222-10M	110	135			
1222-10N	110	135			
1222-10O	110	135			
1222-10P	110	135			
1222-10Q	110	135			
1222-10R	110	155			
1222-10S	135	155			

Table 5. Gear Model/Unit for Standard Fans and Low Sound Fans



## Detailed Component Maintenance Procedures

### Fan Drive System

Optional Gear Drive System



**NOTE:** For projects with whisper quiet fans, please contact your local BAC Representative.

# Fan Guard Installation

**DANGER:** Fan guard must be securely in place before the cooling tower is placed in operation. Never step or walk on the fan guard. Failure to follow these instructions may result in serious injury or death.



If the fan guard is removed or if the fan guard installation is altered for any reason, the fan guard must be reinstalled properly in accordance with the instructions below. Never step or walk on the fan guard. Refer to **Table 6** for the number of fan guard pieces Series 3000 Cooling Towers will have.

Model Number	Number of Fan Guard Pieces
S3E/XES3E-8518-xxx	1
S3E/XES3E-1020-xxx, 1222-xxx, 1424-07x	2
S3E/XES3E-1424-12x, 1424-13x, 1424-14x	4

Table 6. Number of Fan Guard Pieces

**NOTE:** Existing 3/8" stud and nut for guard mounting at fan deck level (3/8" x 1 1/2" bolt for fan guard mounted on top of the cowl extensions).



## One-Piece Fan Guard

Mount fan guard to unit as illustrated in Figure 6, Detail A, at each mounting location around the guard perimeter.

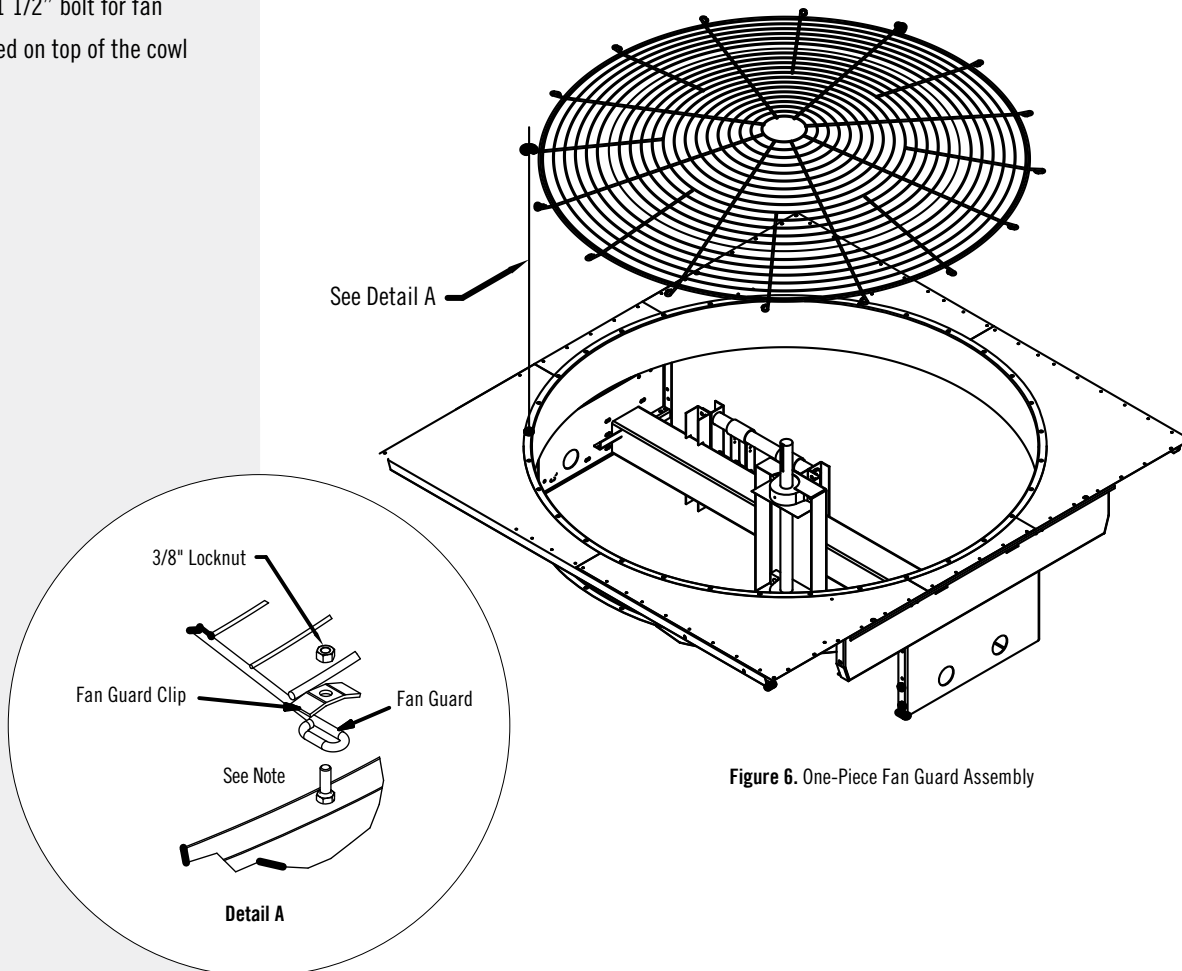


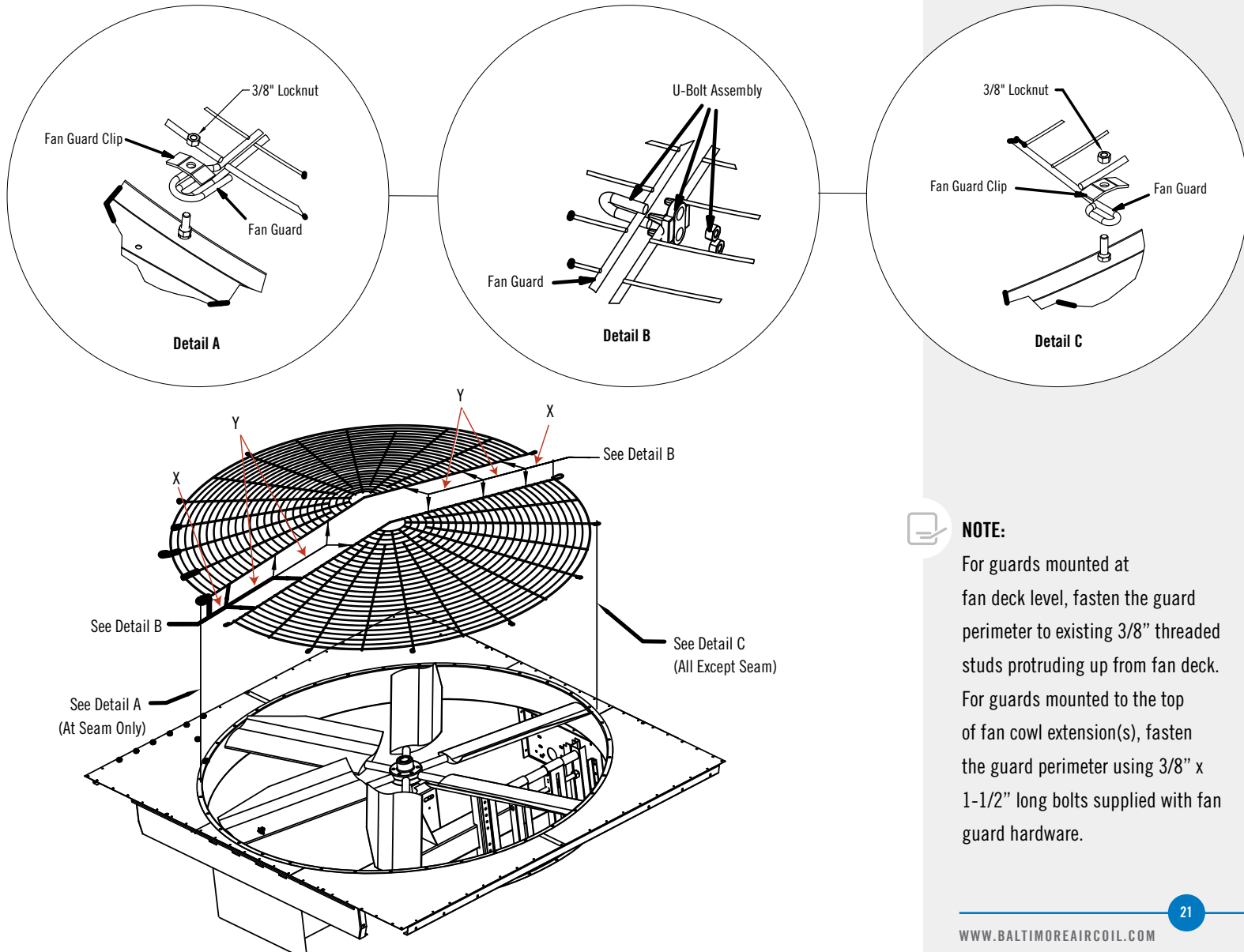
Figure 6. One-Piece Fan Guard Assembly

## Two-Piece Fan Guard

- Using six U-bolt assemblies, fasten the two halves of the fan guard together as illustrated in **Figure 7, Detail B**. Locate the U-bolt assemblies along the seam between the two guard halves per the X and Y dimension provided in **Table 7**, which are based on the diameter of the supplied fan.
- Gradually tighten both nuts of the U-bolt assembly, alternating from one to the other, until 20-25 ft-lb of torque is achieved.
- Mount the fan guard to the unit as illustrated in **Figure 7, Detail A** for the ends of the seam where the two guard halves join together, and **Detail C** for all other locations around the fan guard perimeter.

Fan Diameter	X	Y
9'	10"	17"
10'	10"	20"
11'	10"	23"

**Table 7.** U-Bolt Location Dimensions for Two-Piece Fan Guard Fastening



**Figure 7.** Two-Piece Fan Guard Assembly



## Detailed Component Maintenance Procedures

### Fan Drive Installation

One-Piece Fan Guard

Two-Piece Fan Guard



**DANGER:** Fan guard must be securely in place before the cooling tower is placed in operation. Never step or walk on fan guard. Failure to follow these instructions may result in serious injury or death.



### NOTE:

For guards mounted at fan deck level, fasten the guard perimeter to existing 3/8" threaded studs protruding up from fan deck. For guards mounted to the top of fan cowl extension(s), fasten the guard perimeter using 3/8" x 1-1/2" long bolts supplied with fan guard hardware.

## Four-Piece Fan Guard

- Assemble fan guard supports as illustrated in **Figure 8, Detail A**.
- Secure fan guard pieces to fan guard supports as shown in **Figure 8, Detail B**.
- Mount fan guard assembly to unit as shown in **Figure 8, Detail C**.

**DANGER:** Fan guard must be securely in place before the cooling tower is placed in operation. Never step or walk on the fan guard. Failure to follow these instructions may result in serious injury or death.

**NOTE:**

- Existing 3/8" stud and nut for guard mounting at fan deck level (3/8" x 1 1/2" bolt for guards mounted on top of cowl extensions).

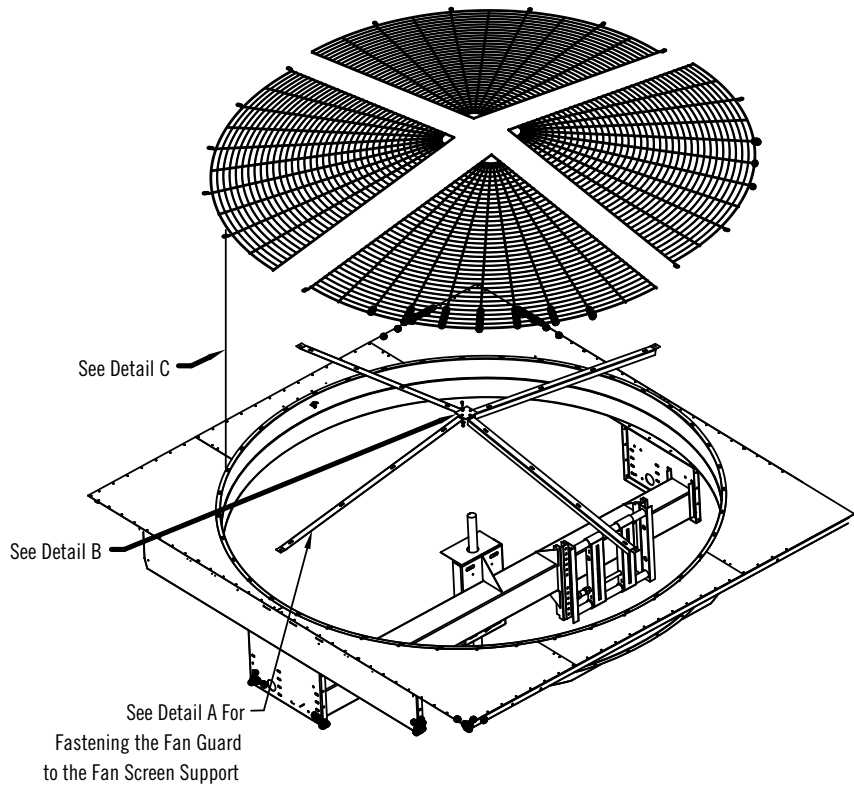
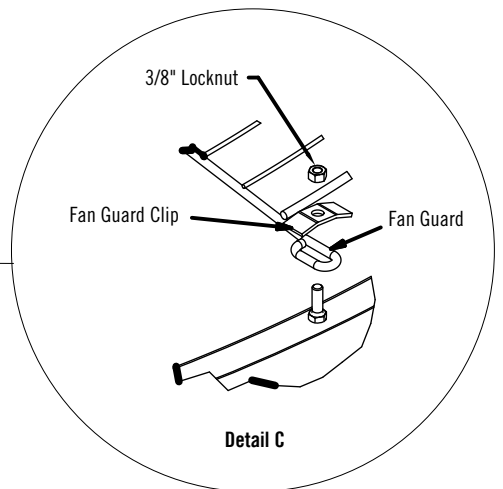
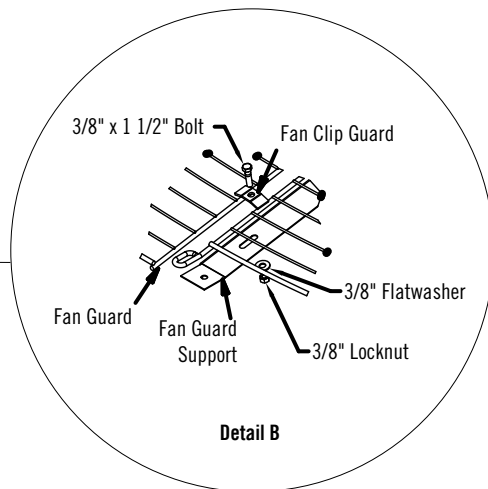
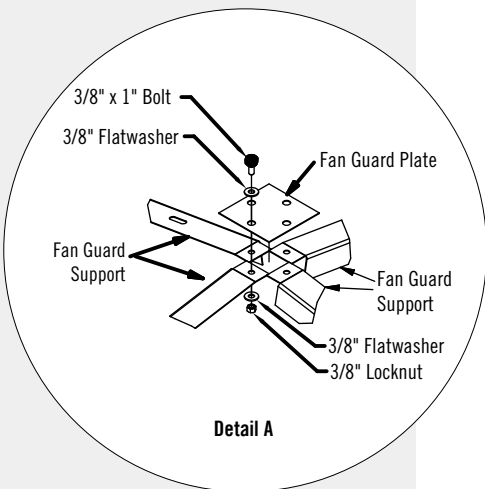


Figure 8. Four-Piece Fan Guard Assembly





# Fan Motors



## Detailed Component Maintenance Procedures

Series 3000 Cooling Towers use cooling tower duty, premium efficient, totally enclosed, motor(s).

### Inspection & Maintenance

- Clean the outside of the motor at least quarterly to ensure proper motor cooling.
- After prolonged shutdowns, check the motor insulation with an insulation tester prior to restarting the motor.
- Check the motor voltage and current following start-up and every three months while in operation.

### Adjustable Motor Base

Coat the motor base slides and adjusting screws prior to start-up, every three months while in operation, and following shutdown. Use good quality corrosion inhibiting grease such as one of those recommended for lubricating the fan shaft bearings.

#### Fan Drive Installation

Four-Piece Fan Guard

#### Fan Motors

Inspection & Maintenance

Adjustable Motor Base

#### Fan Shaft Bearings

Inspection & Maintenance

Adjustable Motor Base

# Fan Shaft Bearings

Two pillow block ball bearings support the fan shaft. Each bearing is equipped with a lubrication fitting and a slinger/locking collar to keep out moisture.

### Inspection & Maintenance

- Only lubricate the bearings with a manual grease gun or BAC's optional Automatic Bearing Greaser. Do not use high-pressure grease guns since they may rupture the bearing seals.
- Only lubricate the bearings with one of the following compatible water resistant greases which are suitable for ambient temperatures ranging from -65°F (-53.9°C) to +250°F (121.1°C).
  - Amoco - Rycon Premium #3
  - Chevron - SRI
  - Citgo - Polyurea MP2™
  - Conoco - Polyurea 2™
  - Exxon - Polyrex® EM
  - Exxon - Unirex N™
  - MobilGrease® - AW2
  - Shell - Gadus S2 V100 3
  - Shell - Gadus S3 T100 2
  - SKF - LGHP2™
  - Unocal 76 - Unilife Grease™



**NOTICE:** Ensure the controls for the fan motor are set to allow a maximum of six on-off cycles per hour to prevent motor overload.



**DANGER:** Rotating equipment will cause severe personal injury or death to persons who come in contact. Do not perform any service, maintenance or inspection on or near the fans, motors, and drives, or inside the unit without first ensuring that the fan and pump motors are disconnected, locked out, and tagged out.



**NOTE:** For programming, operation, and trouble shooting of the greaser, consult the user manual shipped with the greaser. This manual is also available through your local BAC Representative.



**NOTE:** Gear oils containing extreme pressure (EP) additives are not recommended, and should never be used on cooling towers with gear drives.

- Lubricate the bearings as follows:
  - **Initial Start-up:** Normally, no lubrication is required since the bearings have been lubricated at the factory prior to shipment. However, if the cooling tower has been stored at the job site or more than three months, both bearings should be lubricated with new grease before initial operation. **When lubricating, purge the old grease from the bearing by gradually adding grease until a bead of new grease appears at the seal on the underside of the bearing.**
  - **Seasonal Start-up:** Purge the bearings with new grease prior to start-up.
  - **Operation:** Purge the bearings with new grease every three months while in operation, or 2,000 hours, whichever comes first.
  - **Extended Shutdown:** Purge the bearings with new grease before and after any prolonged storage or downtime.

## Heat Transfer Section

### Fill & Drift Eliminator

The Series 3000 has PVC fill with integral drift eliminators.

### Inspection & Maintenance

- Inspect and clean the fill with the integral eliminators at least quarterly.
- The inspection procedure is as follows:
  - Shut-off the fan and the system pump.
  - Inspect the fill for obstructions, damage and fouling.
- Remove any obstructions from the fill.
- Remove any minor fouling chemically. Contact your local water treatment consultant for advice.
- Major fouling requires cleaning and flushing.

## Water Distribution System

### Hot Water Basin

The hot water basins are located on the fan deck. The system water enters the cooling tower through the hot water basins (refer to **Figure 9, page 25**). A series of nozzles, which distribute water over the fill, are located in the hot water basin. There are four materials of construction for the hot water basin: Galvanized steel, Thermosetting Hybrid Polymer, Type 304 stainless steel and Pultruded Fiberglass Reinforced Polyester (PFRP).

## Operating Level

At design flow, the operating level should not be less than 2 inches or greater than 6 inches deep.

## Inspection and Maintenance

- Quarterly, or more often as required, remove any dirt or debris which may clog the nozzles. Seasonally, clean and flush the hot water basin with fresh water.
- Access to the nozzles requires removal of the hot water basin covers.
  - To remove the covers turn the knobs to remove the threaded studs (**Figure 9**). Then, lift the hot water basin covers vertically by using the attached handles. Once the hot water basin covers are removed, the nozzles may be cleaned.
- If access to the nozzles under the pre-distribution chamber is required, remove the hardware that fastens the tabbed baffles, then remove the panels. Retain the hardware to re-install the tabbed baffles.

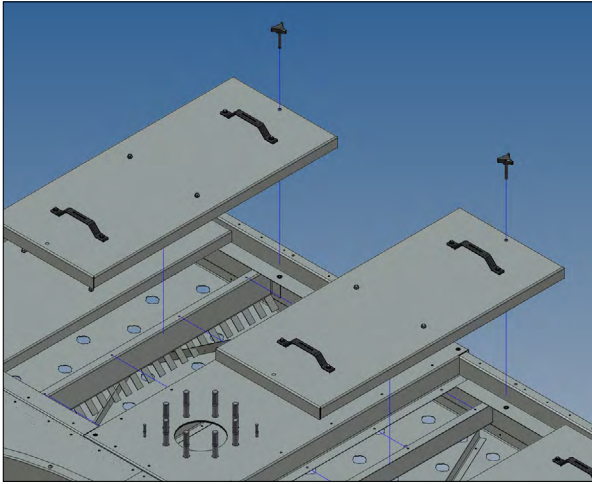


Figure 6. Hot Water Basin Cover Removal

## Optional EASY CONNECT® Piping Arrangement

The Series 3000 Cooling Tower has an optional EASY CONNECT® Piping Arrangement, which is equipped with a capped cleanout connection. The water to be cooled enters the tower through a single connection and passes through the EASY CONNECT® Chamber, supplying water to both hot water basins. See **Figure 10, page 37**.

## Water Level Control

**There are two types of water level controls used on Series 3000 Cooling Towers:**

- Mechanical make-up valve assembly
- Optional electric water level control package

The Series 3000 water make-up valve assembly is located at the connection end of the unit.



## Detailed Component Maintenance Procedures

### Fan Shaft Bearings

Inspection & Maintenance

### Heat Transfer System

Fill & Drift Eliminator

### Water Distribution System

Hot Water Basin

Operating Level

Inspection and Maintenance

Optional EASY CONNECT®

Piping Arrangement

### Water Level Control



**NOTICE:** Do not use steam or high pressure water to clean PVC eliminators or materials other than steel.

## Mechanical Make-up Valve Assembly

A float-operated mechanical water make-up assembly is furnished as standard equipment on the cooling tower. The standard make-up assembly consists of a corrosion resistant make-up valve connected to a float arm assembly actuated by a polystyrene-filled plastic float. The float is mounted on an all-thread rod held in place by wing nuts. The cold water basin operating water level can be adjusted by repositioning the float and all-thread rod using the wing nuts provided.

- Inspect the make-up valve assembly monthly and adjust if necessary.
- Inspect the valve annually for leakage. Replace the valve seat if necessary.
- Maintain the make-up water supply pressure between 15 psig and 50 psig for proper operation. BAC recommends a pressure regulator valve (provided by others) for pressures over 50 psig.
- Set the initial basin water level by adjusting the wing nuts so that the make-up valve is completely closed when the water level in the cold water basin is at the operating level as stated in **Table 1** on **page 9**.
- With the design thermal load and the average water pressure (15 to 50 psig) at the valve, the above setting will produce operating water levels as stated in **Table 1**.
- If the thermal load is less than the design load at the time of unit start-up, the procedure may produce operating levels greater than those shown in **Table 1**. If operating levels are higher than specified, readjust the float in order to attain the recommended operating level.
- Closely monitor the water level in the cold water basin and adjust the level if necessary during the first 24 hours of operation.
- Operating at the recommended water level will ensure that the unit basin contains sufficient water volume to prevent air entrainment in the circulating pump during system start-up and provides sufficient excess basin capacity to accept the total system pull-down volume.

**NOTE:** If the unit has been ordered with the optional electric water level control package or is intended for remote sump application, a mechanical water make-up valve will not be provided.



## Optional Electric Water Level Control Package

As an option, an electric water level control package is available in lieu of the mechanical make-up assembly. The package consists of a probe-type liquid level control assembly and a slow-closing solenoid valve. Stainless steel electrodes, factory-set at predetermined lengths, extend from an electrode holder into the cold water basin. For more information, refer to the *Electric Water Level Control Operation & Maintenance Manual* available at [www.BaltimoreAircoil.com](http://www.BaltimoreAircoil.com).

- Clean the stainless steel electrodes periodically to prevent accumulations of scale, corrosion, sludge, or biological growth, which could interfere with the electrical circuit.
- The water level is maintained at the recommended operating level regardless of the system thermal load. Therefore, it is not recommended that the operating level be adjusted.
- During the start-up of units equipped with the electric water level control package, bypass the control unit in order to fill the unit to the overflow connection.

## L.E.D. Status Codes

- **L.E.D. on steady:** Indicates normal operation.
- **Steady one second flashing:** Indicates dirty probes, reading in the capacitance mode. The unit will still operate but will give the following status code of 1 second on, 1 second off (steady 1 second flashing). This status code will continue until the probes are cleaned and the power has been reset. Note: No other status codes will be displayed until the dirty probes are cleaned.
- **Two flashes and off for 5 seconds:** Indicates make-up valve ran for more than 1 hour. The unit will continue to fill, with the following status code of 1 second on, 1 second off, 1 second on and then off for 5 seconds before repeating. This status will continue until power has been reset. *Possible causes:* leaking tank, obstructed fill / defective valve or reduced flow rate.
- **Three flashes and off for 5 seconds:** Indicates shorted probes or high conductive water. The unit will continue to operate but will give the following status code of 1 second on, 1 second off, 1 second on, 1 second off, 1 second on and then off for 5 seconds before repeating. This status will continue until the water is diluted or the short is removed from the probes and power is reset.
- **Four flashes and off for 5 seconds:** Indicates black probe (P6) reads covered, but White probe (P5) does not read covered (White should also be covered because it is longer than the Black). This will cause the fill solenoid valve to short cycle and lead to premature failure of the fill valve. The unit will short cycle and give the status code of 1 second on, 1 second off, 1 second on, 1 second off, 1 second on, 1 second off, 1 second on and then off for 5 seconds before repeating. The unit will continue short cycle until the condition has been corrected (clean white probe) and reset the power.
- **L.E.D. does not come on after power up or resetting power:** Indicates unit inoperative.



## Detailed Component Maintenance Procedures

### Water Level Control

Mechanical Make-up Valve Assembly

Optional Electric Water Level Control Package

L.E.D. Status Codes

# 3

## SERIES 3000 COOLING TOWER

# Corrosion Protection

BAC products are constructed of corrosion-resistant materials. The fill is made of a polyvinyl chloride (PVC), which is not susceptible to rot, decay, rust or biological attack. Other materials listed below are used in the equipment construction:

- **Galvanized Steel Components:** Inspect the galvanized steel components for blemishes or corrosion. Wire brush and recoat the affected areas with a cold galvanizing compound such as zinc rich compound (ZRC).
- **Thermosetting Hybrid Polymer Components:** Inspect the galvanized steel components protected with the thermosetting hybrid polymer for scratches, scrapes, or blemishes. To cosmetically touch up these areas with color matched paint use BAC Part #160133 available from your local BAC Representative.
- **Stainless Steel Components:** Inspect stainless steel components for signs of blemishes or corrosion. See “Long Term Care of Stainless Steel” **page 31** for cleaning and care instructions.
- **Fiberglass Reinforced Polyester (FRP) Components:** Series 3000 Cooling Towers are provided with FRP casing panels as standard. Inspect the casing panels for accumulation of dirt and clean them with soap and water as necessary.
- **TriArmor® Corrosion Protection System:** Inspect components protected with the TriArmor® Corrosion Protection System for signs of deep scratches or blemishes, especially in areas with field penetrations. Touch these up with 3M™ Windo-Weld™ Super Fast Urethane which is available through your local BAC Representative (BAC Part # RK1015).
- **Pultruded Fiberglass Reinforced Polyester (PFRP) Components:** Units are optionally provided with PFRP hot water basins. Inspect the basin panels for accumulation of dirt and clean them with soap and water as necessary.

**NOTE:** Since the quality of the ambient air and make-up water varies significantly from job site to job site, BAC strongly recommends obtaining the services of a water treatment specialist prior to the initial start-up of the evaporative cooling equipment. Additionally, to protect against the risk of Legionella contamination, never operate the cooling equipment without adequate biological control.



## Water Treatment

A proper water treatment program, administered under the supervision of a competent water treatment specialist, is an essential part of routine maintenance to ensure the safe operation and longevity of evaporative cooling equipment, as well as other system components.

In evaporative cooling products, cooling is accomplished by evaporating a small portion of the recirculating water as it flows through the unit. As the water evaporates, the dissolved solids originally present in the water remain behind and if not controlled, the concentration of dissolved solids will increase rapidly. This can lead to corrosion, scale or biological fouling which may negatively affect heat transfer as well as the longevity of system components.

- **Corrosion** – Red rust on steel components and white rust on galvanized surfaces may affect the longevity of system components.
- **Scale Formation** – Scale, typically a calcium or magnesium based build-up, not only reduces heat transfer and system efficiency, but also may lead to under deposit corrosion. If scale is not controlled, it may continue building on critical components such as the fill and severely impact thermal performance.
- **Biological Fouling** – Slime and algae formations may reduce heat transfer, promote corrosion, and harbor pathogens such as Legionella.



## Water Treatment

- To control corrosion and scale, maintain the water chemistry of the recirculating water within the parameters listed in **Table 8** on the following page. The specific measures required vary from system to system and are dependent on the chemistry of the make-up water, the metallurgy of the piping and heat transfer devices exposed to the recirculating water, and the temperatures at which the system will be operating.
- Bleed/blowdown, the continuous flow of a small portion of the recirculating water to a drain, is used to control the concentration of dissolved solids. On rare occasions, this may be adequate to control scale and corrosion. More often, chemical scale and corrosion inhibitors are necessary, which raise the allowable level of dissolved solids without the risk of scale and corrosion.
- Keep the chemically treated water within the guidelines given in **Table 8**. In cases where bleed/blowdown alone is being employed for corrosion and scale control without chemical treatment your water treatment specialist may recommend more conservative limits than those shown in **Table 8**.

**NOTES:**

1. Galvanized steel units require passivation in order to prevent white rust (refer to “Passivation”).
2. Hardness and alkalinity limits may be exceeded under certain circumstances. Consult your water treatment specialist for recommendations.
3. The conversion factor used to determine conductivity is 0.625 (TDS = 0.625 x Conductivity).
4. EVERTOUGH™ Construction units have a TriArmor® Corrosion Protection System basin.
5. The guidelines above refer to the materials used in construction. Different combinations of materials may be used on the same unit.
6. Water chemistry will change with operating temperatures. The recommended guidelines listed in **Table 2** refers to water temperature at 95°F.



Property of Water	Recommended Levels for Various Materials of Construction			
	Galvanized Steel	Thermosetting Hybrid Polymer	Type 304 Stainless Steel	TriArmor® Corrosion Protection System or Type 316 Stainless Steel
pH	6.5 to 9.0 <sup>[1]</sup>	6.5 to 9.2 <sup>[1]</sup>	6.5 to 9.2 <sup>[1]</sup>	6.5 to 9.5 <sup>[1]</sup>
Total Suspended Solids	25 ppm	25 ppm	25 ppm	25 ppm
Total Dissolved Solids (TDS)	1,500 ppm	2,050 ppm	2,050 ppm	2,500 ppm
Conductivity	2,400 (micromhos/cm)	3,300 (micromhos/cm)	3,300 (micromhos/cm)	4,000 (micromhos/cm)
Alkalinity as CaCO <sub>3</sub>	500 ppm <sup>[2]</sup>	600 ppm <sup>[2]</sup>	600 ppm <sup>[2]</sup>	600 ppm <sup>[2]</sup>
Calcium Hardness as CaCO <sub>3</sub>	50 to 600 ppm <sup>[2]</sup>	50 to 750 ppm <sup>[2]</sup>	50 to 750 ppm <sup>[2]</sup>	50 to 750 ppm <sup>[2]</sup>
Chlorides (CL)	250 ppm	300 ppm	300 ppm	750 ppm
Sulfates	250 ppm	350 ppm	350 ppm	750 ppm
Silica	150 ppm	150 ppm	150 ppm	150 ppm

**Table 8.** Quality Guidelines for Circulating Water

## Chemical Treatment Requirements

Chemical treatment programs must meet the following requirements:

- The chemicals must be compatible with the unit materials of construction as well as other materials used in the system (pipe, heat exchanger, etc.).
- BAC discourages acid dosing as means of scale control except for open circuit cooling towers with remote sump applications or towers constructed from stainless steel. This should be done at a point in the system where total mixing and dilution occur before reaching the evaporative cooling equipment. The preferred injection point for chemical scale and corrosion inhibitors is on the discharge side of the system circulating pump(s). These chemicals should not be batch fed directly into the unit’s cold water basin or water distribution system, as this can severely damage areas directly contacted.
- When chlorine is added to the system, free residual chlorine should not exceed 1 ppm, except as noted in start-up and shutdown section on **Page 5**. Exceeding this limit may accelerate corrosion.



# Passivation



## Corrosion Protection

### Water Treatment

### Corrosion and Scale Control

### Chemical Treatment Requirements

### Passivation

### Biological Control

When new systems are first commissioned, special measures should be taken to ensure that galvanized steel surfaces are properly passivated to provide maximum protection from corrosion. Passivation is the formation of a protective, passive, oxide layer on galvanized steel surfaces. To ensure the galvanized steel surfaces are passivated, the pH of circulating water should be kept between 6.5 and 8.2 and calcium hardness between 50 and 600 ppm (as CaCO<sub>3</sub>) for four to eight weeks after start-up, or until new zinc surfaces turn dull gray in color. If white deposits form on galvanized steel surfaces after the pH is returned to normal service levels, it may be necessary to repeat the passivation process. In case the pH can't be kept below 8.2, a secondary approach is to conduct a chemical passivation using inorganic phosphate or film-forming passivation agents. Consult your water treatment specialist for specific recommendation.

# Biological Control



**NOTE:** Stainless steel cold water basins and basins protected by the TriArmor® Corrosion Protection System or thermosetting hybrid polymer do not require passivation. However, if the upper structure is galvanized steel, passivation is required on the galvanized area including any Hot Dip Galvanized After Fabrication (HDGAF) coil(s).

- The warm, oxygen and nutrient rich environment inside evaporative cooling equipment provides an ideal environment for the growth of algae, slime, and other microorganisms. Uncontrolled, this can reduce heat transfer, promote corrosion, and promote the growth of potentially harmful organisms such as Legionella. To avoid biological contamination and minimize the risk of Legionella, initiate the biocide treatment program at start-up and continue on a regular basis thereafter in accordance with the treatment supplier's instructions.
- Bleed/blowdown or chemical treatment used for corrosion and scale control alone is not adequate for control of biological contamination.
- Introduce solid or granular biocides through a chemical "pot" feeder installed in parallel with the system circulating pump. Diluted liquid biocides may be added directly to the cold water basin.
- If ozone water treatment is used, at no point should concentrations exceed 0.5 ppm to avoid corrosion.

# Long Term Care of Stainless Steel

When the percentage of chromium in steel exceeds 10.5%, it is called stainless steel. The chromium in the steel reacts with the oxygen in the air to form a chromium-oxide surface layer, also called the passivation layer that provides the corrosion resistance in stainless steel.

## BAC's Manufacturing Process

BAC takes precautions to prevent cross-contamination, processing galvanized and stainless steel parts separately. Also, stainless steel brushes are used to clean welds on stainless parts and care is taken to avoid scratching parts during processing. Organic cleaners are used to clean the finished product prior to shipping.

### Jobsite Considerations

While stainless steel itself does not rust so long as the chromium-oxide surface layer is intact, it is not immune to contamination from its surroundings. Some common sources of surface contamination are:

- Dirt and soil
- Shop oil or grease that may carry other contaminants such as metal chips
- Machining or welding galvanized steel at the jobsite may cause debris to embed itself into the stainless steel


These contaminants can deposit on the surface and scratch the passivation layer or prevent it from re-forming. They can also get trapped underneath the passivation layer and reduce corrosion resistance.

## Recommended Cleaning Procedure

Stainless steel needs to be cleaned regularly to maintain the corrosion resistance as well as to maintain the overall aesthetics of the stainless steel.

It is fairly simple to clean most contaminants off the surface of stainless steel. Most dirt and soil can be cleaned with a clean cloth, warm water, and mild detergent. For persistent dirt, a little vinegar can be added in the cleaning water. It is important to always rinse the surface with warm water and wipe with a dry cloth after any cleaning, whether mild or aggressive.

- Fingerprints, mild stains or grease spots can be cleaned using organic solvents such as acetone, methyl or ethyl alcohol, or mineral spirits. Stainless steel wipes or glass cleaners commonly available in stores may also be used.
- Occasionally the surface of stainless steel can get iron chips or shavings embedded in it from having galvanized steel machined or welded in the vicinity. The iron chips can start to rust, reducing the corrosion resistance of the stainless steel, and stain the surface giving the impression that the stainless steel is rusting. These types of contaminants require more aggressive cleaning. Mild abrasives such as Scotch-Brite™ products may be used where aesthetic considerations are not important followed by solvent cleaning with organic solvents as described above. It is important to rinse the surface with warm water and wipe with a dry cloth after cleaning.
- If the iron chips are not removed with the Scotch-Brite™ Products, electro-chemical cleaning may be required. BAC uses commercially available equipment for electro-chemical cleaning in the field. Contact your local BAC Representative for more information or to arrange a service call.



**NOTICE:** Never use chloride or chlorine based solvents such as bleach or muriatic (hydrochloric) acid to clean stainless steel. It is important to rinse the surface with warm water and wipe with a dry cloth after cleaning.

# Bleed Rate



In evaporative cooling, evaporation of a small portion of the recirculating spray water as it flows through the equipment causes the cooling effect. As this water evaporates, the impurities originally present remain in the recirculating water. The concentration of the dissolved solids increases over time and can reach unacceptable levels. In addition, airborne impurities are often introduced into the recirculating water. If these impurities and contaminants are not effectively controlled, they can cause scaling, corrosion, and sludge accumulations that reduce heat transfer efficiency and increase system-operating costs, potentially shortening the useful life of the equipment. The degree to which dissolved solids and other impurities build up in the recirculating water may be defined as the cycles of concentration. Specifically, cycles of concentration equal the ratio of the concentration of dissolved solids (for example - chlorides, sulfates, etc.) in the recirculating water to the concentration of the same material in the make-up water.

- In order to optimize heat transfer efficiency and maximize equipment life, bleed or blowdown a small amount of recirculating water from the system. This controls the cycles of concentration to maintain the quality of the recirculating water within the guidelines given in **Table 8**, on **page 30**.
- Replenish the “bleed” water with fresh make-up water, thereby limiting the build-up of impurities.
- Bleed/blowdown:
  - Accomplish the bleed automatically through a solenoid valve controlled by a conductivity meter. The set point is the water conductivity at the desired cycles of concentration and should be determined by a competent water treatment expert.
  - Alternatively, use a bleed line with a valve to continuously bleed from the system. In this arrangement, adjust the rate of bleed using the valve in the bleed line. Measure the rate of bleed by filling a container of known volume while noting the duration. Check the bleed rate and water quality periodically to ensure that adequate control of the water quality is being maintained.



**NOTE:** A proper water treatment program, administered under the supervision of a competent water treatment specialist, is an essential part of routine maintenance to ensure the safe operation and longevity of evaporative cooling equipment, as well as other system components.



**NOTE:** The solenoid valve and conductivity meter must be supplied by others. Evaporation is proportional to the load and will vary seasonally. BAC recommends the use of a conductivity meter to maximize water conservation.

**Bleed Line Calculations:** Bleed rate is determined by the following formula:

$$B = \frac{E}{(n-1)}$$

**Where:** B = Bleed Rate (USGPM)

E = Evaporation Rate (USGPM) = Q (USGPM) x R (°F) x 0.001

Q = Process Fluid Flow Rate (USGPM)

R = Range

n = Number of Cycles of Concentration = CR/CM

CR = Concentration in Recirculating Water

CM = Concentration in Make-up Water

**Given:**

- S3E-8518-05M Cooling Tower
- Process Fluid Flow Rate = 800 USGPM
- Maximum Allowable Chloride Concentration = 250 ppm
- Concentration of Chlorides in Make-up Water = 45 ppm
- Range = 10°F

**Find:** Bleed Rate

**Solution:** So in this case,

$$E = Q * R * 0.001 = 800 * 10 * 0.001 = 8 \text{ USGPM}$$

$$n = \frac{CR}{CM} = \frac{250 \text{ ppm}}{45 \text{ ppm}} = 5.55$$

$$B = \frac{E}{(n-1)} = \frac{8 \text{ USGPM}}{(5.55-1)} = 1.75 \text{ USGPM}$$

Therefore, in this case we must bleed approximately 1.75 USGPM to limit the concentration of impurities.

This example focuses on a single parameter (chloride concentration) of water only. The bleed rate required for a system (when evaluating more than one parameter) is the highest bleed rate required to keep all parameters within recommended limits.

**NOTE:** The evaporation rate (E) can be determined by any one of the following methods:

- The evaporation rate is approximately 2 USGPM per 1 million BTUH of heat rejection.
- The evaporation rate is approximately 3 USGPM per 100 tons of refrigeration.
- Evaporation Rate =  $Q \text{ (USGPM)} * R * 0.001$ .

**NOTE:** Evaporation is proportional to the load and will vary seasonally. BAC recommends the use of a conductivity meter to maximize water conservation.

# Cold Weather Operation



## Inspection & Maintenance

BAC products can be operated at subfreezing ambient temperatures provided proper operating methods are established and diligently followed.

- Carry out frequent visual inspections and routine maintenance services during operation in subfreezing weather.
- Ensure all controls for capacity and freeze protection are set properly and functioning normally.
- Prevent excessively high water levels and possible overflow of the cold water basin due to over pumping, clogged strainers, or make-up valve malfunction.
- Some unit icing can be expected in very cold weather. Usually this will not effect the operation of the unit. Resolve any icing conditions that may damage the unit or the supports, impair the system performance, or create a safety hazard.

## Fan Section Icing Protection

There are two basic operational methods which can be used to provide the system's required cooling: temperature setting and fan control. The method of control employed on a given application depends upon the climatic extremes which are expected, the variations in heat load that will be encountered, and the compatibility of the control system with other portions of the installation.

In subfreezing ambient temperatures, effective icing control may require a combination of these two methods. Operate each unit with the highest thermal load it can handle, rather than evenly dividing the total heat load across all cells. During prolonged cold weather periods, bypass the idle units and drain the basins.

### Temperature Setting

Low leaving fluid temperatures promote ice formation. During operation in subfreezing ambient temperatures, maintain the leaving water temperature as high as possible. Ensure the unit operates with the maximum possible heat load. The recommended minimum process fluid temperature is 43°F (6.1°C).

## Fan Control

The following are fan control methods to reducing icing:

- **Variable Frequency Drives:** See **page 40** for information.
- **Multi-Speed Motors:** If the unit is equipped with 2-speed motors or BALTIGUARD™/ BALTIGUARD PLUS™ Fan System, operation at a lower speed may be sufficient to prevent icing. The motor starter should include a minimum 15 second time delay when switching from high to low speed.
- **Fan Cycling:** Set the controls to allow a maximum of six on-off cycles per hour. Cycle the fan off for five minutes every 15 to 20 minutes for each cell. If ice continues to build on the air intake, decrease the on-time. Observe the air intake of the unit at least every four to eight hours.
- **Fan Reversal:** This procedure should be used only after the other methods of fan control fail. If utilized, the fans should be run in reverse for no longer than 20 minutes at no more than 50% speed, and the cooling tower should be observed during this time. Before returning to normal operation, visually inspect the fan blades for ice formation.

**NOTICE:** When reversing the direction of rotation, allow the fan to come to a complete stop before restarting the motor.



## Basin Water and Internal Piping Freeze Protection

### Cold Water Basin Protection

It is important to protect the basin and internal piping. The basin water could freeze when the unit is shut-down and exposed to subfreezing ambient temperatures.

- **Remote Sump:** The ideal method of protection is a remote sump located in a heated indoor space. When the circulating pump stops, the water in the connecting piping will drain by gravity to this indoor sump.
- **Basin Heaters:** On applications without a remote sump, heat must be provided to the cold water basin. Electrical immersion heaters can provide the required function. Contact your local BAC Representative for details.
- **Electric Water Level Control:** An electric water level control will maintain the proper water level regardless of the thermal load or variations in make-up water supply pressure. The two-position, slow closing solenoid valve provided with the BAC electric water level control package also minimizes valve freezing problems (see **page 26**).
- **Heat Tracing:** Heat trace and insulate all exposed water piping including pump piping below the overflow level and make-up water lines with electrical heater tape.



**NOTE:** For remote sump applications, the water level in the basin of the equipment is a function of the design flow rate, the quantity, size and location of the remote sump connection and the pipe design between the cooling tower and the remote sump. Units installed on remote sump applications are supplied without a make-up connection.

## Freeze Protection for the Optional EASY CONNECT® Piping Arrangement

- Eliminate all water in the optional EASY CONNECT® Piping Arrangement and in all internal piping when the tower is idle.

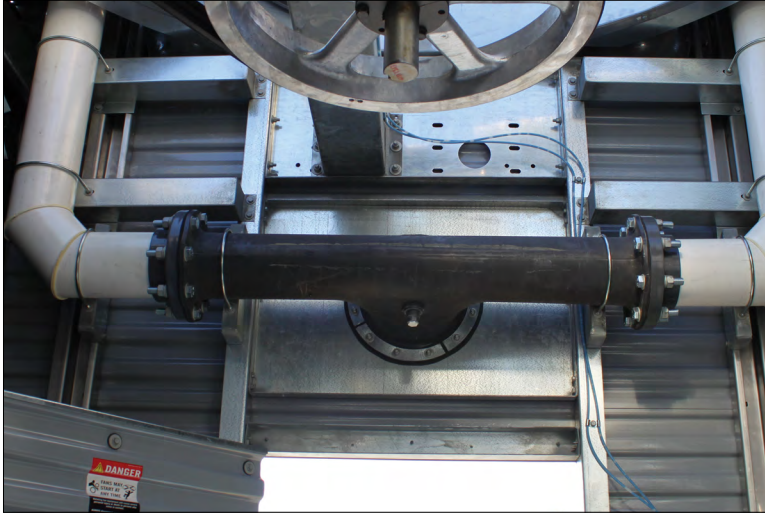


Figure 10. Optional EASY CONNECT® Piping Arrangement

- It is essential to drain water from the EASY CONNECT® Piping Arrangement and internal piping whenever the potential for freezing temperatures exists. Drain the water by using 1/2" NPT drain port located on the inboard side of the EASY CONNECT® Piping Arrangement.
- There are three recommended methods for draining the piping:
  - Preferred: Install a normally open 1/2" solenoid valve on the 1/2" drain connection of the EASY CONNECT® Piping Arrangement. Wire the valve in the pump circuit so the valve closes when the pump is energized. Select the solenoid valve to operate with a minimum pressure differential of 0 psi, which is required to limit the static head imposed on the valve from the water column.
  - Install a 1/2" manual valve on the 1/2" drain connection of the EASY CONNECT® Piping Arrangement. Open the valve during the cold weather operation. Keep the valve closed during the warm weather to achieve full thermal performance.
  - Remove the 1/2" plug from the 1/2" drain connection of EASY CONNECT® Piping Arrangement during the cold weather operation. Reinstall the plug during the warm weather to obtain full thermal performance.



## Cold Weather Operation

### Fan Section Icing Protection

Fan Control

### Basin Water and Internal Piping Freeze Protection

Cold Water Basin Protection

Freeze Protection for the Optional EASY CONNECT® Piping Arrangement



**NOTE:** Modulating the water flow rate to the unit is NOT a recommended method of controlling cooling capacity.

# Operation Considerations for Accessories

## Basin Heater (Optional)

One or more electric immersion heaters prevent the cold water basin from completely freezing over and damaging the unit during shutdown or standby. The heaters are sized for the specific unit. The heating element has an enclosure that is suitable for outdoor use. Annually, inspect the basin heater prior to the risk of reaching freezing operating conditions.



Figure 8. Basin Heater

**NOTICE:** The basin heater is not designed to prevent icing during unit operation.



### Operation

Ensure that the heating element is completely submerged before energizing the main disconnect. For installations that have a BAC Controls Enclosure, please consult the submittal package provided with the unit and contact your local BAC Representative for support. For installations that use a stand alone BAC heater control panel, see below.



# Stand Alone BAC Heater Control Panel (Optional)



## Operation Considerations for Accessories

The heater control system consists of a heater control panel and a combination temperature/water level sensor. The stainless steel sensor probe with 1/2" NPT mounting fitting has an on/off relay output that de-energizes the heaters whenever the basin water temperature is above 45°F (7.2°C), or whenever the sensor probe is not fully submerged. The control panel enclosure is suitable for outdoor use.

The control system utilizes a combination temperature/low water level control sensor, which is powered by a transformer in the control panel. When the sensor provides a signal to the control panel, the panel sends a control voltage to the magnetic contactors. When energized, the magnetic contactors supply line voltage to the heaters. Annually inspect the heater control system prior to the risk of reaching freezing operating conditions.

### Operation

Ensure that the element is completely submerged before energizing the main disconnect. The combination temperature/low level control is preset to energize the heater at 40°F (4.5°C), but will not energize if the water level is too low or if the water temperature is above 45°F (7.2°C).

#### Testing the heater when water temperatures are above 45°F (7.2°C):

- Disconnect the heater control panel and tag out the circuit.
- Remove the heater control panel cover.
- Remove the sensor wires connected to terminals T1 and T2 on the combination temperature/low level control and isolate them.
- Install the 1.5K ohm test resistor supplied with the heater control panel (in bag on outside of cover) across terminals T1 and T2.
- Install the heater control panel cover.
- Energize the system and listen for the contactor closing.
- After operation, de-energize the circuit, disconnect the heater control panel, and tag out the circuit.
- Remove the resistor and place it back in the storage bag. Check all connections, reconnect sensor wires per the wiring diagram to terminals T1 and T2, replace the cover, and place the system back in service.

#### Operation when the sensor probe is encased in ice:

- Disconnect the heater control panel and tag out the circuit.
- Remove the heater control panel cover.
- Install a jumper wire across terminals G1 and G2 on the combination temperature/low level control circuit board.
- Install the heater control panel cover.
- Energize the system and listen for the contactor closing.
- Operate the system until the ice is melted around the probe.
- After operation, de-energize the circuit, disconnect the heater control panel, and tag out the circuit.
- Remove the jumper, check all connections, replace the cover, and place the system back in service.



**WARNING:** Dangerous voltages are present in this equipment. Disconnect the electrical service of the source and tag the circuit out before servicing or replacing components.



**Notice:** Do not operate the system unattended or for extended periods of time during test mode (resistor across terminals T1 and T2). Operation in water temperatures above 45°F (7.2°C) could damage the unit.



**Notice:** Do not operate the system unattended or for extended periods of time with terminals G1-G2 jumpered. A low liquid level condition could occur, and the system will not shut off which could result in damage to the heater and unit.

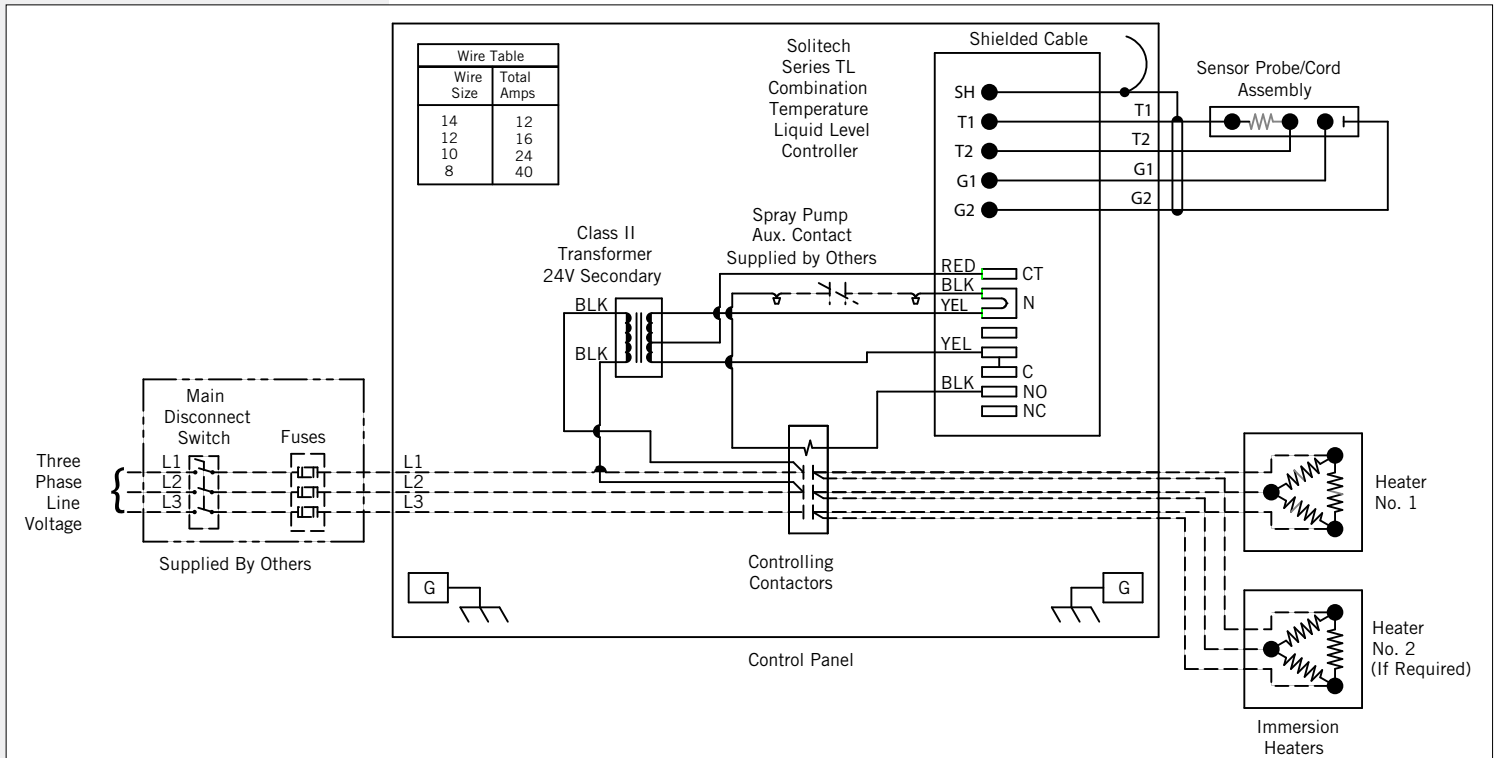


Figure 12. Example Wiring Diagram for Stand Alone BAC Heater Control Panel (Refer to Submittal Drawing for Specific Wiring Diagram)

**NOTE:** Figure 12 is superseded by any drawing supplied with the panel by the manufacturer.



## Vibration Cutout Switch (VCOS)

The Mechanical Vibration Cutout Switch and the Optional Electronic Vibration Cutout Switch should be tested and field adjusted at start-up and yearly thereafter.

### Mechanical Vibration Cutout Switch (Optional)

#### Set Point Adjustment When Installed:

1. For safety, turn off, then lock and tag-out the electrical supply to the fan motor(s).
2. Turn adjustment screw counterclockwise 1/8 turn at a time until you hear the control trip.
3. Once tripped, rotate adjustment screw 1/4 turn clockwise. Push in the manual reset button.
4. Start up the fan(s) to determine if the start-up will cause the cut-out switch to trip.
5. If the VCOS does not trip, start and stop the fan two more times. If the VCOS still does not trip, then calibration is complete.
6. If the VCOS trips, repeat steps 1 through 5 until calibration is complete.



### Stand Alone BAC Heater Control Panel

Operation

### Vibration Cutout Switch

Mechanical Vibration Cutout Switch (Standard)

Electronic Vibration Cutout Switch (Optional)



**NOTICE:** The heater control panel temperature/low level control can only be used with the supplied combination temperature/liquid level sensor probe. Please contact your local BAC Representative for replacement parts.

### Electrical Reset and Start-up Lockout (Optional):

1. If rated voltage is continuously applied to the reset circuit at unit start-up, the reset solenoid energizes for a fixed time interval (approximately 30 sec), after which time the solenoid is automatically de-energized by the thermistor. This provides a trip lockout during machine start-up roughness.
2. The voltage must be removed from the reset circuit when the machine is stopped to allow the thermistor to cool off.
3. The switch mechanism can be reset electrically by a momentary application of the reset voltage or it can be reset manually.

### Electronic Vibration Cutout Switch (Optional)

Two models of electronic vibration cutout switches are available. The single set point model contains one trip limit for shutdown. The dual set point model contains two independent trip limits; one for alarm and one for shutdown. The shutdown set-point is factory set at 0.45 in/sec. Additional details can be found in the submittal packet.

**WARNING:** Before performing an adjustment or inspection of the VCOS, make certain that all power has been disconnected and locked in the off position. Moisture inside the switch can lead to switch failure. Care must be taken when replacing the cover on the vibration switch to ensure that the proper watertight seal is obtained.

#### Testing:

- The test position sets in the minimum set point so that any vibration will cause a trip condition.
- The light will come on immediately, and the trip will occur after the duration of the time delay, proving the complete system is operational.
- If test position is maintained for less than the duration of the time delay, the trip will not occur, thus permitting the system test without shutdown.

#### Calibration:

- A light adjacent to the set point control comes on the instant the measured vibration level exceeds the set point.
- The unit can be periodically calibrated on line by turning the set point control down until the light comes on. This setting is then compared with the vibration measured with a portable vibration meter, thus providing a calibration check of the unit.
- If the trip setting is maintained, trip will occur after the duration of the time delay.

**Remote Reset:** Connection between terminals 6 and 7 latches electromechanical relay output in alarm state after set point is exceeded. Opening the connection will reset the output to non-alarm state.

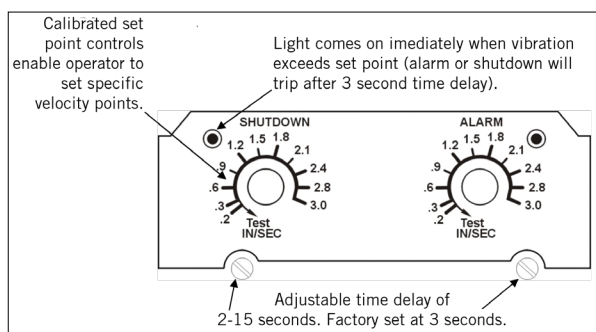


Figure 13. Electronic VCOS with Alarm Contact is Shown

# Fan Control

## Variable Frequency Drive Operation

**NOTICE:** For a unit with a VFD, with a switching frequency of 2.5 kHz, the line lead length cannot exceed 100 feet. If the switching frequency is higher than 2.5 kHz and/or the line lead length exceeds 100 feet, a dV/dT output filter is recommended to protect the motor. Since the switching frequency and maximum line length requirements vary between VFD and motor suppliers, contact your local BAC Representative to determine if a dV/dT filter is required.

**NOTE:** The minimum turndown ratio for units with a belt drive is 10:1 (or 6 Hz). The minimum turndown ratio for units with gear drive is 4:1 (or 15 Hz), unless supplied with an oil pump or a no minimum speed gear. Units with the oil pump do not have a minimum speed.

**NOTE:** For more information on the VFD for the ENDRUADRIVE™ Fan System, refer to **page 13**.

- Applications utilizing variable frequency drives (VFDs) for fan motor control must use inverter duty motors built in compliance with NEMA standard MG-1, Part 31.
- Operation of the unit at a speed which resonates with components of the drive system or support structure may result in vibrations which could damage the components or structure, and/or create objectionable noise. Therefore, these resonant speed ranges should be identified at start-up and locked out to prevent operation of the motor at these resonant speeds. The “Resonant Speed Identification Procedure” must be conducted on **page 43**.
- Please refer to the manufacturer’s variable frequency drive recommended start-up procedure for further information or consult with your local BAC Representative for any VFD applications. For projects with BAC controls, visit [www.BaltimoreAircoil.com](http://www.BaltimoreAircoil.com).

### Optional Gear Drive Units with VFDs

- Do not operate the standard gear drives below 450 RPM motor speed (gear input speed). For speeds less than 450 RPM, a low speed option gear drive must be supplied.
- Continued operation at a speed which resonates with the gear drive system may result in torsional vibrations which can damage system components. The most common indicator of torsional vibration is an unusual rumbling or grinding noise from the gear drive at a narrow speed range. The noise will decrease to normal levels when the speed is increased or decreased away from the resonant speed range. This noise is not indicative of a defect, but results when the vibratory torque exceeds the drive torque, causing the gear teeth to separate and clash together very rapidly. On variable frequency drive applications, avoid operation near this resonant speed by locking out the resonant speed range.

# Resonant Speed Identification Procedure



## Fan Control

### Variable Frequency Drive Operation

Optional Gear Drive Units with VFDs

### Resonant Speed Identification Procedure

There are several characteristic frequencies at which vibration levels may resonate with unit structural components. These include fan speed, motor speed, bearing frequency, and blade pass frequency. Within the overall operating speed range of a unit, it is not unusual for one or more of these characteristic frequencies to excite the structural components over relatively small speed ranges and create an increase in vibration levels. If the vibration levels are excessive at these resonant speeds, they need to be locked out to prevent the VFD from operating the motor at these speeds. The following procedure describes how to identify the lockout speed ranges:

- Ensure the VFD that controls the fan motor is off, and the power to the motor circuit is locked out.
- Depending on the type of drive system (gear or belt), Attach the accelerometer (provided by others) onto the box beam as shown in **Figure 14a or 14b**. The accelerometer should be located away from the center of the web of the box beam, such that the center line of the accelerometer is about 1 inch from the upper or lower edge, as shown.



**NOTE:** The resonant speed identification procedure must be performed at start-up for units with VFDs.



Figure 14a. Accelerometer Location - Gear Drive

Correct accelerometer location, 1" from the edge of the box beam

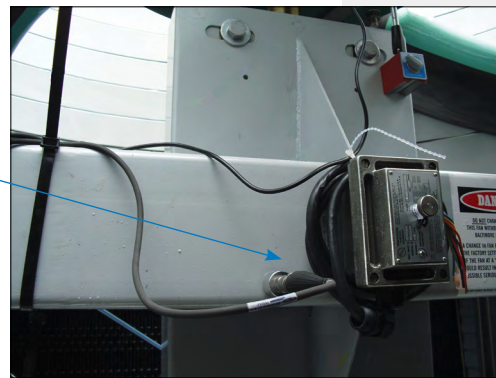


Figure 14b. Accelerometer Location - Belt Drive

- Connect the signal wire from the accelerometer (provided by others) to the vibration analyzer (provided by others). Be sure to route and fasten the wire so that it will not contact any rotating parts inside the unit when the drive system is operational.
- Get out of the unit, and ensure that the drive system is “all clear”. Remove the lockout from the motor circuit.
- With the VFD off, record the vibration level indicated on the vibration analyzer, and confirm that it is very low (only picking up ambient vibration). Record this overall vibration level (O-peak) in inches per second (ips). If the ambient vibration level is greater than 0.35 ips, identify and correct the cause of the vibration. It could be vibration transmitted from another source, instrumentation malfunction, radio frequency interference, etc. If the cause is vibration transmitted from another source, and that source cannot be isolated or turned off for the duration of the measurements, note the source and magnitude of the vibration before continuing.
- After it is confirmed that the drive system is “all clear” and the unit access doors are closed, turn the VFD on, and verify that the fan is turning in the correct direction.
- Using the VFD, slowly (about 1 RPM increase every five to ten seconds) adjust the motor speed from the lowest limit to full speed while monitoring the vibration levels. Record the overall vibration levels at regular intervals if desired.

- As stated previously, when adjusting the VFD speed, proceed slowly while monitoring the vibration levels. If the vibration value approaches 0.35 ips (O-peak), slowly “zero in” on the speed where the value equals 0.35 ips, and record the speed at which this occurs as the lower end of the lockout range. Also record the vibration level at this speed.
- Continue to slowly increase the speed while monitoring the vibration level. If this is a resonance, then the value should peak and eventually decrease to a level that is below 0.35 ips as the speed is increased. After the vibration level has peaked and continues to fall, record the speed where the value equals 0.35 ips as the upper end of the lockout range.
- Using this data, a baseline for vibration history can be developed. The vibration levels can be monitored yearly and the trend used to indicate potential wear or the need to replace components in the drive system.
- After the entire speed range has been checked and any resonances identified, ensure the VFD that controls the fan motor is then turned off, and the power to the motor circuit is locked out.
- Enter the unit, and carefully remove the accelerometer, along with any associated wiring from the unit.
- Work with the VFD contractor to enter the lockout speed ranges into the VFD, so the unit will not operate at a resonant speed.
- Once it has been verified that the drive system is all clear, return the unit to its normal operating condition.
- Keep a record of any lockout speed ranges for future reference.

# New Field Connections for TriArmor

The following are installation instructions for adding new field connections (Equalizer/Bypass/Outlet) on a cold water basin with the TriArmor® Corrosion Protection System.

Supplies Provided by BAC	Recommended Supplies Provided by Others
Template for the connection with bolt holes	Stainless steel threaded shoulder bolts
Type 304 stainless steel backing ring with gasket	150 lb flange, weld any piping to the flange prior to installation
Vulkem® caulk	Gasket for the outside of the cold water basin

Table 9. Supplies for Installing Field Connections

1. Use the BAC template provided with the accessory to layout and mark the hole pattern on the exterior of the cold water basin.
2. Drill a pilot hole from the outside of the cold water basin to the inside of the cold water basin.
3. On the inside of the cold water basin:
  - a. For connections 3” or less, score the TriArmor® Corrosion Protection System with a hole saw as shown in **Figure 15**.
  - b. For connections 3” or greater, proceed to step 4 and 4b.
4. Cut the hole from the outside of the cold water basin.
  - a. Use a hole saw or a step drill bit for smaller connections 3” or less as shown in **Figure 16**.
  - b. Use a reciprocating saw or a Sawzall® for larger connections 3” or greater.
5. Position the BAC supplied stainless steel backing ring gasket to the inside of the cold water basin.
6. Position the flange to the outside of the cold water basin.
7. Bolt the flange and the stainless steel backing plate together using stainless steel bolts.
8. Seal any exposed galvanized steel of the connection inside the cold water basin with Vulkem® caulk as shown in **Figure 17**.

**NOTE:** BAC recommends adding a flange connection for field installed equalizers, bypass and outlet connections. Please order the recommended supplies listed in **Table 9** prior to unit shutdown.



Figure 15. Scored TriArmor® Corrosion Protection System



Figure 16. Removal Material

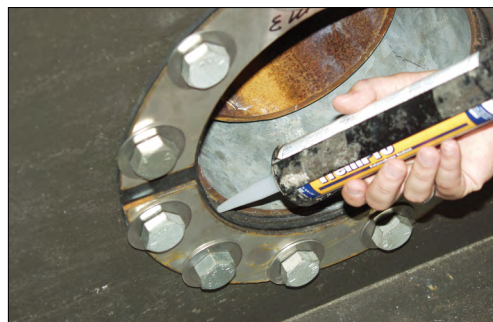


Figure 17. Caulk Exposed Galvanized Steel

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