Appendix V

GEA Power Cooling: Cooling Tower Operating and Maintenance Instructions

OPERATION AND MAINTENANCE MANUAL

FOR

Project Name:	**EMPIRE**
Location:	**Rensselaer, NY**
Contract/PO #:	
GEA Power Cooling Inc. REF:	**#CY 07-007**

Revision 0

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I. INTRODUCTION

I.1. COOLING TOWER SPECIFICATIONS AND EQUIPMENT DATA SHEET

IF ANY DIFFICULTIES OR PROBLEMS OCCUR, CALL:
GEA POWER COOLING INC.
1-303-987-0123

Tower Model No.	484854-11I-30-FPF
Customer Name	LG Constructors / Empire Generating Co.
Customer Order Number	PO 3604732006 & SUB 3604734002
GEAPC Job Number	07-007
Location	Rensselaer, NY
Completion Date	AUG 2009

PERFORMANCE DATA

Water Circulation	127,000 gpm
Inlet Water Temperature	102.3 °F
Outlet Water Temperature	76.5 °F
Design Wet Bulb Temperature	41 °F
Evaporation Rate	2122 gpm
Pump Head	43 ft
Design barometric Pressure	29.914 in Hg
Plume Design Factors – Wet Bulb / Relative Humidity	41.09°F /59.78 %

TOWER DESIGN DATA

Type	Fiberglass Plume-Abated Counter Flow
No. of Cells	11
Cell Size	48 ft x 48 ft
Overall Length/Width	528 ft x 48 ft
Basin Curb to Distribution Center Line	19 ft 4.75 in
Air Inlet Height	11 ft
Fan Deck Height	54 ft
Fan Stack Height	10 ft
Distribution Type	Downspray
Drift Eliminator Type	SDRU Plus
Access to Top of Tower	1 Stair Tower
Fill Type	OF21MA
Fill Height	5 ft
Fan Deck Live Load/psf	60 lb/ft^2
Snow Load	65 lb/ft^2
Design Wind Velocity	90 mph

MATERIALS

Tower Structure .... Class 1 FRP
Bolting Hardware 316SS
Nailing Hardware 316SS
Base Anchors 316SS
Joint Connectors 316SS
Gear Support Members .... Epoxy Painted Carbon Steel
Fan Stack/Type .... FRP – Butt Flanged
Distribution Headers .... FRP – Class 1
Distribution Lateral Lines .... PVC SCH 40
Distribution Spray Nozzles .... Polypropylene
Drift Eliminators .... 0.010 mil AF/PVC
Fill .... 0.015 mil BF/PVC
Casing .... 12 oz. Fire Retardant 4.2
Fan Deck; Partition & Wind Wall .... Class 1 FRP; 12 oz. F/R 4.2
Coil Tube Sheet/Tubes 316SS
Coil Headers .... Epoxy coated HDG Steel

FAN DATA

Manufacturer .... Howden
Model 30-SX-6
Diameter .... 30 ft
Blades/Fan 6
Blade Material .... FRP
Hub Material .... Epoxy Coated Carbon Steel
Fan Speed .... 85 rpm
Tip Speed .... 8011 ft/min
Outlet ACFM/Fan at Design Conditions .... 1,204,794.9 ft^3/min
Total Static Pressure Drop .... .5151 in. of H_2O
Design Fan Pitch .... 20.1°

GEAR/DRIVE SHAFT DATA

Gear Manufacturer .... Amarillo
Model 1713A
Rated Capacity .... 205 Hp
Reduction Ratio 13.582:1
Lubrication Type .... Splash
Drive Shaft Manufacturer .... Addax / Rexnord
Material .... Composite / 316SS
Service Factor .... 2.0 minimum
Vibration Switch .... Metrix 440SR

MOTOR DATA

Manufacturer.. Reliance Electric
Enclosure .... TEFC-Severe Duty
Frame Size 449T
Rated Capacity 200Hp
Operating Speed 1200rpm
Phase/Cycle/Volts.. 3/60/480
Space Heater Voltage...120V

VACUUM SYSTEM

Vacuum Pump Manufacturer / P/N .... Unique Systems / 10-CW-LSHL
Enclosure ....TEFC
Rated Capacity ....5.0 hp
Operating Speed 1750
Phase/Cycle/Volts.. 3/60/460 VAC
Vacuum System Tubing/Piping Material 316SS

HEAT EXCHANGE TUBE BUNDLES

Bundle Manufacturer..Cooler Services
Tubes .... 316 SS
Fins ....Extruded Aluminum
Tube sheet..HDG steel
Headers...Bolt-on Bonnet Epoxy coated carbon steel
Frame..HDG steel
Temp in/out..102.3°F / 95.57° F
Design water flow ....2886.7 gpm per bundle
Design air flow ....754,257 lb/hr per bundle

LOUVERS

Louver Manufacturer...GEA / CSC
Blade Material... Aluminum
Frame Material ....HDG steel
Hardware ....HDG steel
Actuator manufacturer / PN..Fisher / 646-60
Actuation .... Pneumatic
Control..TBA

EQUIPMENT

The Empire plume abatement system consists of the following hardware:

Vacuum pump – Unique Systems / 10-CW-LSHL
Seal Water Control Solenoid Valves – 6223G10
Flow Switch – FX-0750-2XJ
Flow Control Valve – 1407099
Vacuum Gauge – 45125988 04L
Vacuum Relief Valve: 1859-125900
Isolation Valves – VEE-2000-0.5
Cell vacuum supply solenoid valves – ASCO/8210G089
Cell water level switches – Magnetrol/962-7DA0-020

The vacuum system (vacuum pump) must be active during all times of plume abatement system need. The vacuum system supplied for Empire is a duty-standby system. Therefore, there are two independent systems (both mounted on one skid). The vacuum pumps require seal water in order to operate properly. The seal water should be supplied from a continuous make-up source (usually the taken from below a riser valve) and requires 1.5 GPM in order to operate properly.

CONTROL LOGIC – Vacuum Pumping System*:*

The system will need primary and secondary pump activation logic. When a pump is activated (manually in control room), the logic must contain an interlock with the seal water flow switch. The pump must not be operated without seal water flow. Once the pump is activated, the control logic must activate the seal water solenoid to begin water flow to the pump. The water flow switch will sense water flow and close. This signal must be received by the control system before the pump motor is allowed to energize. The seal water flow switch interlock must be maintained at all times of operation. If water flow is terminated, the control system must shut-down the pump. Again, there are two identical systems supplied on the pump skid. Vacuum system pressure is controlled and monitored with a vacuum bleed valve and pressure gauge, located on the skid inlet pipe. No control logic is required for this part of the system. The vacuum bleed valve can be manually adjusted if required. During initial startup, the bleed valve should be adjusted to between 15-20 in.HgV; no additional adjustment should be necessary.

A level switch and a solenoid valve control the vacuum supplied to each cell. During start-up the solenoid valve and level switch will both be in an open condition. The level switch is located in each cell in a standpipe at the high point of the cooling tower distribution. Once the cell fills with water the level switch will close sending a signal to the DCS to close the solenoid valve. When entrained air in the system collects in the standpipe and the water level drops, the level switch will open sending a signal to the DCS to open the solenoid valve. The valves will cycle most during startup operations, but are operational at all times to remove transient air introduced in the system. 120VAC power is required for the solenoid and level switch. In the event that during operation a cell needs to be shut down, provision must be made in the control logic to close the solenoid valve.

I.2. A SHORT DESCRIPTION OF A COUNTERFLOW COOLING TOWER

A Cooling Tower consists of the following:

A. A concrete, fiberglass or wood framework with fiber-reinforced, plastic, corrugated siding.
B. A system of water distribution pipes and nozzles within the framework.
C. A heat exchange medium (the fill) made up of modular PVC material.
D. A basin to collect the cooled water and direct it back to the circulating pumps.
E. Fans to move the air necessary for proper heat exchange.
F. Drift Eliminator medium to prevent water droplets from escaping from the tower in the air flow.
G. A dry section for winter months when water vapor plume is visible.

Operation of the tower centers around exposing warm water to moving air, to effect an evaporative, or latent, heat transfer. This heat is dissipated into the atmosphere. Keep the tower clean and the water distribution uniform to obtain continued maximum cooling capacity. Do not allow excessive deposits of scale or algae to build up on the fill media or the drift eliminators. Keep all nozzle orifices free of debris to assure correct distribution and cooling of water.

The water to be cooled is transported to the distribution level by riser pipes external to the tower. It flows from the risers into a horizontal distribution header pipe. From there it branches into a system of lateral distribution pipes, where nozzles spray the water upward or downward in a predetermined pattern over the heat exchange medium, or fill.

Before the air flow is permitted to exit through the top of the tower, it must pass through the drift eliminators. These are simply blocks of material shaped to cause the air to change directions and thus provide impact surfaces, which prevent water droplets from being carried out of the tower with the air flow.

The falling water is caught by the cold water basin, which then directs the flow back to the circulation pumps. The normal water depth in the tower is about 6-12" below top of curb. Adjust make-up water supply to maintain this water level.

The capacity of a tower to cool water to a given cold water temperature varies with the wet-bulb temperature and the heat load on the tower. As the wet-bulb temperature drops, the cold water temperature also drops. However, the cold water temperature does not drop as much as the wet-bulb temperature. A tower does not control heat load. The quantity of water circulated determines the cooling range for a given heat load. The hot and cold water temperature increases with higher heat loads.

Wet-bulb temperature:	the temperature indicated by the wet-bulb thermometer of a sling or mechanically aspirated psychrometer. Also, an indicator of the capacity of the ambient air to receive an amount of water vapor and heat.
Cooling range:	the temperature difference between the hot water coming into the cooling tower and the cold water leaving the tower.

Refer to the Performance Curves in this manual for cold water temperature at varying flow rates and varying range.

A cooling tower emits a stream of hot air at a specific humidity during normal operation. If the humidity level is not lowered, the water content in the exit airflow condenses and may form a visible plume. This phenomenon is more dramatic during cold months. The theory is that air enters the tower at a certain wet bulb, dry bulb and relative humidity. As the air travels through the tower, its properties change. Upon exit, the air is higher in temperature and humidity compared to inlet air. As a result, the outlet air combines with ambient air eventually returning to the inlet air conditions. A plume is visible if the maximum relative humidity resulting from the mixing of the tower and ambient air is greater than one hundred percent. A good example is rainy days. Based on a number of environmental influences, if the relative humidity is high enough and the temperature is lower than the dew point of the air mass, it will rain. Rain is the result when the air has reached its saturation point. The same concept applies here for cooling towers. Since the air cannot hold any more moisture, the droplets have to condense to form dew or a visible plume.

The plume abated cooling tower lowers the temperature and relative humidity of the outlet air flow. With the plume abatement system in operation, the outlet air will not be at a plume condition.

How does the plume abatement system do this? The tower incorporates the use of a wet section and a dry section. The wet section is for the normal operation of the cooling tower (i.e., the cooling function of the tower). The dry section is for the winter months when a plume is more likely to be visible. The dry section utilizes coils to dry ambient inlet air. In other words, the air leaving the dry section will be at a lower relative humidity and a higher than ambient temperature. The two air streams mix and in reaching equilibrium the resulting outlet air mass is at a lower characteristic state, i.e., not saturated. With a wet section and a dry section, the two air masses mix and the result is a change in properties of the combined flow thus lowering the outlet state of the air and eliminating any plume at the design condition.

II. OPERATION PROCEDURE

II. 1. PRE-STARTING PROCEDURE

Follow all parts of this operating procedure to insure maximum life of your GEA Power Cooling, Inc. cooling tower. For any situations not covered in this manual, call GEA Power Cooling, Inc. direct in Lakewood, Colorado 1-303-987-0123. Please reference the GEA-PC tower model number and order number regarding questions concerning this tower or for ordering spare parts.

Safety

While any portion of the tower is down, barricade any access openings or fan stack openings during down period. While inspecting or maintaining any section of mechanical equipment, lockout/tagout motors at fan disconnect box or motor control center (MCC) with guaranteed procedures to prevent accidental unlocking. Also, lockout/tagout riser valves when maintaining the distribution system or heat transfer media. Follow all OSHA regulations and standards including use of safety harnesses where appropriate.

Cleaning

Remove any debris or trash from top of fill. After circulating water is flowing, visually inspect distribution for any clogged nozzles. Replace or clean any clogged nozzles. Remove any sediment from the cold water basin, sump and screens.

Inspection

All operating components must be inspected before they are placed in operation. Specifically check all of the following:

1. Inspect all safety devices and interlocks to insure they are wired and functioning. Safety devices such as the gear reducer oil level switch or the fan vibration switch must never be bypassed to expedite a start-up.

2. Check drive shaft alignment. Re-align per the manufacturers operation and maintenance instructions, if necessary.

3. Check tightness of bolts that attach steel fan drive supports to the tower.

4. Check tightness of bolts at fan cylinder joints and anchorage.

5. Check tightness of the following bolted joints in the fan and drive assemblies:
   a. fan hub clamp bolts
   b. fan hub cover bolts
   c. gear reducer and motor mounting bolts
   d. drive shaft coupling and guard bolts.

6. Check gear reducer oil for sludge or water by draining off and testing a sample. Check gear reducer oil level at the fill plug and sight glass at gear reducer. Add oil as required. Check external sight glass for correct position of oil level.

7. Rotate fan by hand to be sure of free clockwise rotation and a tip clearance of approximately 1" when viewed from above.

8. Lubricate the motor according to motor manufacturer's instructions.

9. Check the fan pitch, per the fan manufacturer's literature - Appendix D.2. Then test run each fan separately for a short time (less than 5 seconds). Check for excessive vibration or unusual noise. If either is present, see Tower Trouble Tips on following pages of this manual.

   Depending on the power demand and the ambient temperature, it may be necessary to adjust the fan pitch. Please note that more power is required to drive the fan with no water on the tower than with water flowing.

10. Check functioning of make-up water supply, blow down, drain and outlet valves.

11. Vacuum pump: Ensure suction is being drawn by checking the Pressure gauge and that seal water is flowing to the vacuum pump

12. Damper actuator inspection: Ensure louvers operate from fully open to fully close and are not damaged or obstructed.

Note: It is recommended that all readings be noted in a log book. Items 5 and 6 are to be made before each start-up.

First time water is turned on.

Fill the cold water basin and circulating water system slightly above the operating water level to allow for drawdown. When filling the water system, make sure to open all riser valves to prevent over-pressurizing on the hot water distribution system.

1. Start-up the circulating water pumps. Under no circumstances should the water from the first start-up be fed to the cells since this water is dirty, may contain debris and is likely to block the nozzles. The water must bypass the tower and must be pumped through the circuit for a minimum of one full cycle through the circulating water system in order to clean the circuit.

2. Maintain observation on the water level in the basin to prevent overfilling if the sump screens were to clog with debris.

3. After the initial flush, the pumps are to be stopped, and the basin emptied and cleaned out.

4. Repeat this process until all significant debris has been removed.

5. Once the basin has been refilled, the tower is ready to go into operation.

II. 2. STARTING PROCEDURE

WARNING:
If restarting after a stoppage under normal operating conditions, continue with this section. If starting after an extended outage or for the first time, conduct section II.1. Pre-starting Procedure before continuing with section II.2.

General

During startup, verify the following:

Check all mechanical equipment to insure no foreign material is obstructing movement of the fans. Remove fan tie-down chains or ropes if being used. Verify oil line isolation valve is open at gearbox location.

Start each fan separately, monitoring the fan for any excessive vibration. Excessive vibration will trip the vibration switch and shut down fan motors. To check operation of vibration cutout switch, remove the switch cover plate and manually adjust the vibration shutdown switch sensitivity setting until switch trips.

Should the vibration switch be inoperative, contact GEA Power Cooling.

Should there be excessive vibration, the cell number should be noted and GEA Power Cooling service department notified.

After five minutes of operation, recheck the gear reducer oil levels.

The fan pitch has been pre-set by GEA Power Cooling to approximate design brake horsepower at full load and design conditions. If all operating criteria including wet bulb and heat load are near design, the fan brake horsepower can be checked. After 30 minutes of operation, the gear oil will be at proper temperature to allow checking of motor wattage, or voltage and amperage, for calculation of brake horsepower. Variations in ambient conditions and hot water temperature from design will affect fan horsepower.

Normal System Startup

When all of the pre-startup items have been checked and are satisfactory, the basin can be filled with water and the tower placed in operation. A step-by-step program follows:

1) To prevent icing, do not attempt to circulate water through the tower unless a heatload is available, the minimum cold water temperature has been reached and/or the ambient air temperature is above 40°F.

2) Both wet-side and dry-side louvers should be closed from the shut-down procedure.

3) If circulating water-piping system is equipped with pump discharge valves, close valves to not more than 25% open before starting pumps to prevent excessive water surge in piping to

the tower. Open the valves full open to the bypass system.

4) Verify the riser isolation valves to all cells are 50% open and all riser drain and pitot tap valves are closed. If the tower is equipped with a bypass system, open bypass valve to 50% open.

5) Once the cold water basin has been filled and the cold water temperature has risen to the minimum level, the circulating water pumps may be started. If more than one pump is used, start incrementally. Slowly open pump discharge valves (on one pump at a time) to one quarter open and hold for several minutes. Then open further to one half open and hold for several minutes. Then open further to three quarters open and hold for several minutes. Then open the remaining quarter until full flow is obtained.

6) Once all pump discharge valves have been opened 100%, the riser isolation valves may be opened 100%. Open the riser isolation valves in the same manner as the pump discharge valves, at one-quarter intervals, holding for hydraulic balance for several minutes between adjustments.

7) Once all pump discharge valves and riser isolation valves have been opened fully and full flow is going to the cooling tower, the cooling tower bypass valves can be closed. The bypass valves should be closed in the same manner that the discharge valves were opened...slowly at one quarter increments and one valve at a time. The cooling tower should be monitored carefully during the opening of the discharge valves and closing of the bypass valves. If pump surge or water hammer is occurring, the tower will likely be damaged and the results of such damage will not be covered under warranty.

8) Verify the vacuum system is active and operating. The vacuum pump should be active and operational at all times while water is flowing through the tower.

9) When the desired cold-water temperature has been achieved and continues to rise, the dry-side louvers should be opened one (1) cell at a time As cold water temperature rise the fans should be started one (1) cell at a time. Repeat until the desired number of fans is running.

10) Once all fans are running, the wet-side louvers may be modulated open as cooling capacity and cold-water temperature needs dictate.

11) When the wet-side louvers are fully open, the dry-side louvers may be closed to provide additional cooling capacity.

Inspect flow and balance flow pattern over the tower visually. Adjust flow with riser valves in each cell until flow appears uniform as viewed through the air-inlet area. Counterflow towers are designed for approximately 2.0 psig (or 5' of head) at the nozzles. Excessive flow rate (greater than 133% of design) is the usual cause of performance problems, drift and physical damage to the distribution system components.

Dry System Operation / Louver Setting

The cooling tower is equipped with electro-pneumatic actuated louvers on both the dry-side heat exchange bundles and the wet-side air inlet. GEA recommends that the dry-side louvers be full open in the winter months and times of cold weather, and fully closed during summer months. However, the louvers are equipped with variable positioners. The operator may adjust position incrementally to control tower plume and cold-water temperature. Water flow is present through the coil bundles whenever the tower is operating. This is to prevent corrosion in the coil bundle system. In freezing conditions, the flow through the dry section should not be allowed to go below 80% of design. This is especially important during startup as cold water with low tube velocity may lead to freezing. Plume can be controlled at any time by opening the dry-side louvers, which controls the amount of airflow over the dry section. Wet-side louvers are provided to control the minimum cold-water temperature and provide additional plume abatement. During the winter months, the wet-side louvers will need to be partially closed to meet the cold-water temperature and plume guarantee.

AT NO TIME, SHOULD THE FANS BE OPERATED WITH BOTH WET & DRY DAMPERS IN THE CLOSED POSITION.

II.3. NORMAL OPERATING PROCEDURE

After the tower has been placed in full operation (see Section II.2 for startup procedure), all systems must be monitored on a regular basis.

Log sheets should be maintained regarding inspection of the cooling tower systems. Items to be included on the log sheets are as follows:

1. Each cell should be given a specific number and I.D.

2. Gears, motors and drive shafts should have an individual I.D.

3. Date and time of inspection.

4. Normal basin water level.

All cooling tower systems are to be checked daily. Items that must be checked include:

1. Gear reducer oil level for each cell.

2. Fan motor operation, i.e. is the fan at full speed or off for each cell. If the fan motor is off, plant operation should be checked to determine the cause. If the motor should be on further investigation must be made.

3. Observe drive shafts for oblong movement or any excessive vibration.

4. All electrical conduit on top of the tower should be visually checked for any excessive corrosion or breaks. (Weekly verification is adequate.)

5. Any excessive noise in either motors or fans should be noted and reported.

6. Water flow observed in air inlet area should be noted as either normal or abnormal. Areas with excessive flow or with very little flow should be noted and reported. Abnormal water loading may indicate distribution system damage.

7. Verify the vacuum system, located on the north end of the cooling tower basin, is operational and seal water flow is present. The pump has a flow switch, which will terminate pump operation if seal water flow is absent.

II.4. WINTER OPERATING PROCEDURE

General

The GEA Power Cooling, Inc. counterflow-cooling tower is specifically designed to reduce icing problems during cold weather operation. The only areas in direct contact with entering air are the louvers at the air inlet opening and the coil bundle surfaces when the dry-side louvers are open. All other components are within the tower and protected as long as the tower is supplied with normal operating heat load. If no heat load is available, the circulating water should be bypassed directly to the cold-water basin and the wet-side louvers closed.

If the tower is not bypassed, water flow rates to the tower must be maintained at the highest operating level. This is to insure full warm water wash of the internal components.

Any formation of substantial size icicles hanging from the bottom of the fill can result in damage to the fill material.

Cold Weather Start-up

With initial start-up of the entire tower or individual cells, general procedures as outlined earlier should be followed. In addition, the following checks should include:

1. Start water flow (in bypass mode) prior to any other start-up. Should there be any ice buildup on the mechanical equipment, the warm air vapor must be allowed to melt the ice prior to any other equipment start-up.

2. If the heat load will be equal to or below 60% load, two (2) cells should be bypassed and only 1 circ water pump used. In this scenario the two (2) cells not being used must also be isolated from the vacuum system. Both the wet & dry-side louvers should be closed on the isolated cells.

WARNING: In freezing conditions if only 1 circ water pump is used, two (2) cooling tower cells MUST be isolated. Failure to do so will cause the tube bundles to freeze due to insufficient water velocity.

3. Once the normal system start-up has been followed and water is running over the tower, check the hot water distribution system for all nozzles at full flow (see troubleshooting section if any nozzles are clogged).

4. Visually inspect the fan and drive shaft for any ice buildup. Start-up with ice on the fan blades or driveshaft can cause an imbalance and damage.

Cold Weather Operation

At design flow, the cold-water temperature should be maintained at 81°F or greater (100% plant load). The temperature should be continuously monitored during critical dry bulb periods. During initial operation the tower should be monitored for excessive ice build-up every 30 minutes.

When the water temperature falls below 81°F at full plant load, the following steps should be taken:

1. If the cold-water temperatures fall below 81°F with all fans off, the wet side louvers should be incrementally modulated closed.

2. The same inspection method should be followed as under pre-starting procedures. In addition, visual inspection of the air inlet area should be made during the coldest hours of the day.

   Any ice buildup on the perimeter columns or the bottom of the fill should be noted and frequently monitored. If ice buildup becomes excessive, begin shutdown procedure as noted above. Do not in any case try to physically remove or strip framework of ice. Melting will leave components in good condition. Physical removal of ice will cause more damage.

3. The mechanical assemblies supplied with this tower are capable of reverse operation and may be used to recirculate warm air in cells that have ice-build-up.

4. During start-up, flow water fifteen minutes with the fans shut off to prevent ice buildup in the plenum area.

5. During freezing conditions the wet-side louvers should be monitored every 30 minutes for ice build up. If no ice build-up occurs in the 1st full week of operation in below freezing conditions the monitoring interval may be changed. At the first sign of louver ice buildup, the louvers should be closed down to allow the ice to melt. In the event that the wet-side louvers are frozen in place, the dry side louvers should be shut and the fans may be put in reverse to recirculate warm air across the louvers and melt the ice. DO NOT attempt to physically remove ice build-up as this could cause louver damage.

6. Prior to restarting fans, fan blades must be visually rechecked to insure there has been no ice buildup.

Transitioning from 6 cells to 8 cells in operation

Once additional heat load is available the cooling tower may be transitioned from 6 cells to 8 cells in operation. The following procedure should be used and followed as heat load and cold water temperature needs dictate.

1. Open the riser isolation valves and start the 2nd circ water pump.
2. Open the vacuum isolation valves to the two cells.
3. Close all eight cells wet-side dampers.
4. Open the dry-side dampers of the two cells that were just brought into operation.
5. As cooling needs dictate, turn on remaining fans 1 at a time.
6. Modulate wet side dampers open to meet cooling and cold-water temperature needs.

CONTROL LOGIC - Louvers

The amount of plume abatement required to reduce plume to acceptable levels is driven by a combination of atmospheric conditions and tower operating conditions. The Dallman Unit 4 coil bundles are provided with electro-pneumatic louver actuators (4-20mA input). Louver position dictates how much air bypasses the wet section of the tower and enters the plenum. GEA recommends that the dry-side louvers be fully open in the winter months and fully closed in the summer months. Each tube bundle heat exchanger (32ea.) has independent control capability (i.e. 32 independent actuators). To add additional plume abatement and to meet the minimum cold-water temperature the wet-side louvers (16 ea) will need to be partially closed. Both the dry-side and wet-side actuators/louvers are designed to fail in place. Means should be provided to operate the louvers together on each side of the tower independently such as ‘east-side wet’, ‘east-side dry’, ‘west-side wet’, and ‘west-side dry’. In the case a cell or cells are shut down, the logic should be able to take these cells out of the logic and operate them independently.

II.5. SHUTDOWN PROCEDURE

Fan Motors and Gear Reducers

Stop all fan motors and energize space heaters.

When the tower is shut down, operate each fan at full speed for towers with single-speed motors for a 20-minute (minimum) period monthly during any extended shut down. *Caution:* Always make sure fan is free to rotate; schedule fan runs in winter only after visual inspection. Manually rotate motor shafts (15 revolutions) monthly if power is temporarily unavailable.

Circulating Water Pumps

Stop all pumps or close all riser valves to the hot water distribution system.

Cold Water Basin

In winter months, to prevent possible basin frost heave, water level in the cold-water basin should be maintained at the normal operating level. The wet-side and dry-side louvers should be fully closed. Draining of the basin should be limited to 3 days or less.

Louvers

During shutdown, both the dry-side and wet-side louvers should be closed.

Vacuum System

The vacuum system should be turned off.

II.6. WATER TREATMENT

Good cooling water is essential to minimize costly repairs to tower components, which can suffer as a result of improper water treatment. The effort spent in the proper treatment of cooling water will be justified by lengthened component life.

Chemical surface attack is commonly caused by water containing a large amount of alkaline compounds and oxidizing agents such as chlorine. This attack is most prevalent in the frequently wetted components, such as framing members. Chemical surface attack is virtually non-existent when the pH is controlled within the range of 6.0 - 8.0 and non-oxidizing chemicals are used to control biological attack.

Biological attack is caused by microorganisms, which selectively attack the cellulose fibers of fiberglass. It is believed that the agents primarily responsible for biological attack, which has been termed "soft-rot," are of the ascomycetes and fungi imperfecti type. This attack is characterized by a dark appearance and a brash condition of the fiberglass surface.

Compounds containing chlorine are generally good algaecides and fungicides. When used, chlorine should be injected on a shock basis. Residual levels of chlorine should be no higher than 1 ppm measured in hot water. Special attention should be paid to where the chlorine is released. Locally, there may be high concentrations of chlorine, which will lower the pH and cause corrosion.

Corrosion of metals in a cooling tower is generally a result of low pH, high oxygen concentrations and carbon dioxide. There are several chemicals that may be used to slow corrosion if there is a problem.

Calcium carbonate is primarily responsible for the formation of scale within a tower. Since the amount that can be dissolved in solution is dependant on temperature, raising the incoming temperature will increase the deposition of scale. Many agents, such as sulfuric acid, are available to control the formation of scale. A water treatment consultant will be able to determine which chemicals best suit each situation as well as how to best add the chemicals.

For additional information on the treatment of the cooling water, contact a reputable cooling water consultant. Federal, state, and local ordinances should be consulted and their limitations on the type and quantity of chemicals permitted in the discharge should govern their selection.

COOLING TOWER WATER - MAKEUP AND BLOWDOWN

Cooling tower water makeup is necessary to replace the water losses as a result of evaporation, blow down, windage, and carryover. The amount of water lost due to evaporation can be roughly estimated at 1% of the flow for every 10°F range of cooling. For a better approach on estimating the amount of loss due to evaporation, the attached curve can be used to determine evaporation loss as a function of the wet bulb temperature and relative humidity. The amount of loss due to carryover and windage is considered negligible with GEA Power Cooling, Inc. cooling towers and can be neglected.

When water evaporates in cooling tower operations, most of the dissolved solids remain behind in a non-evaporative state. If the ratio of these concentrates becomes great enough, scale and deposits will form in heat exchanger tubes and other piping systems. This can result in reduced flow at higher backpressure. To reduce concentration of solids, cooling tower blow down is required.

To calculate the amount of blow down required in GPM, the attached evaporation curve and the following equation may be used:

(1) $$\text{Blow down (GPM)} = \frac{\text{Evaporation}}{(N-1)}$$

Where:

N = # cycles of concentration

Normally, the user should attempt to maintain the cycles of concentration ratio at a range of 2-10.

The total makeup, therefore, results as the combination of evaporation and blow down as follows:

(2) Total Makeup (GPM) = Evaporation Loss + Blow down (1)

$$\text{Makeup} = \frac{\text{Evaporation} \times N}{(N-1)}$$

During scheduled plant shutdowns, the user should clean the cold water basin to remove excess sludge and solids. This is best accomplished by shoveling out the heavy sludge first, then washing and scraping concrete walls and basin floor with a high pressure water hose.

II.7. WIND AND SEISMIC RESPONSE PROCEDURES

General

The GEA Power Cooling, Inc. counterflow cooling tower is specifically designed to withstand the forces induced by wind and seismic events in accordance with the codes and standards contained in the technical specifications. However, there may be transient occurrences whereby the forces on the cooling tower may exceed the design basis. Under these circumstances, the following is recommended.

High Wind Event

Should a high wind event be anticipated, the following response procedure shall be used:

1. Perform the Shutdown Procedure in Section II.5.

2. One half of the total number of blades in each assembly should be secured to the cooling tower framework using restraining cables, ropes, etc., to prevent the fan from rotating. These restraining devices shall be installed in such a way as not to expose the blades to excessive forces which could damage the individually secured blades (i.e. install the devices so as not to cause blade deflection in excess of its at-rest position).

3. After the event has passed, remove the restraining devices from the fan blades and thoroughly inspect the fan assembly and fanstack for damage. Inspect the remaining cooling tower components for visual damage.

4. If no damage is discovered, perform the Starting Procedure in Section II.2. However, the mechanical systems should be monitored for excessive vibration for a period of 24 hours.

Seismic Event

Should a significant seismic event occur, the following response procedure shall be used.

1. Perform the Shutdown Procedure in Section II.5 as quickly as practical.

2. After the event has passed, thoroughly inspect the fan assembly and fanstack for damage. Inspect the remaining cooling tower components for visual damage.

3. If no damage is discovered, perform the Starting Procedure in Section II.2. However, the mechanical systems should be monitored for excessive vibration for a period of 24 hours.

III. MAINTENANCE INSTRUCTIONS

III.1. PRE-OPERATION MAINTENANCE INSTRUCTIONS

The following instructions are a CHECK LIST for the Owner to provide proper care and maintenance of tower components after tower completion until commercial operation.

COMPONENT	INSTRUCTIONS	DOCUMENTATION
1. Motors	a) Manually (or by power) rotate motor shafts weekly, at least 15 revolutions, until commercial operation. (Note: Owner immediately prior to commercial operation, to remove bearing grease, clean bearings, and regrease if Owner determines this is necessary.	a)______________*
2. Fans	a) Prior to commercial operation and at intervals not exceeding 6 months thereafter, check tightness of fan blade clamp hardware.	a)______________*
3. Drive Shafts	a) Check drive shaft couplings every 6 months for cracked bushings, looseness of bolts, and misalignment.	a)______________*
4. Gear	a) Operate each fan (half speed and/or full speed) for 3 hours minimum period monthly to recoat all interior surfaces of gear reducers with oil. Make sure oil level is at full mark at the gear reducer and that the external sight glass full mark corresponds with the full level in the gear reducer. Note: Schedule fan runs during winter after visual inspection to avoid possible unbalance from ice or snow that may have previously accumulated on fan.	a)______________*
	b) Maintain log sheets of daily inspection of gear oil line sight gauge to insure proper oil level.	b)______________*
	c) During inactivity corrosion will form on the surface ofthe gearbox output and input shaft. Upon start-up this corrosion will abrade and, potentially, damage the output and input seals. To prevent this, if the gearboxes will not be operated for more than two weeks, a preservative lubricant must be applied around the output shaft from approximately 1" away from the seal to and overlapping the seal. This preservative lubricant layer must be inspected periodically and renewed as required to maintain a seal against moisture.	c)______________*

*** Owner to maintain log of this activity.**

III.2. PERIODIC MAINTENANCE INSTRUCTIONS

Unit Maintenance

Well maintained equipment gives the best operating results and the least maintenance cost. We recommend setting up a regular inspection schedule to insure effective operation of the cooling tower.

We recommend Owner to keep a continuous lubrication and maintenance record for the cooling tower.

Hot Water Distribution - The distribution nozzles should be checked monthly for partial or total blockage. Note, any plugged nozzles by location and remove and replace plugged nozzles with new ones. The nozzles must be kept in place to assure proper water distribution.

Tower Framework - Keep framework bolts properly torqued so as not to crack the FRP structure. Pay particular attention to bolts in the mechanical equipment supports.

Drive Shaft - Check drive shaft alignment and condition of couplings every six months. See drive Shaft Service Manual, Appendix D.6, for correcting misalignment, balancing or replacing parts.

Electric Motor - Lubricate and maintain each electric motor in accordance with the manufacturer's instruction, Appendix D.3. If repair work is necessary, contact the nearest representative of the motor manufacturer.

Casing - The casing normally requires no particular maintenance. Any damage to the casing, besides causing additional water losses, will result in an uncontrolled air intake which may be detrimental to the thermal efficiency of the tower. It is thus necessary to make the repairs as soon as possible.

Drift Eliminators - We recommend that the drift eliminators be kept clean by removing mosses, algae or muds which might accumulate on them. These accumulations increase the pressure loss through the drift eliminators and therefore are detrimental to tower efficiency. If the drift eliminators are accidentally damaged, it is necessary to make the repairs quickly to avoid excessive drift losses.

Fans - The fan manufacturer’s installation instructions are enclosed, Appendix D.2. As a general rule, it is strongly recommended to check the torque of all bolts used for assembling the various fan elements, such as blades and hubs, during the second month after a new tower is put into operation. The torque shall be according to the value given in the operating instructions. It is advisable to check this at least once a year.

Do not climb on the blades or use them as a scaffolding support or working platform. The blades must be kept clean in order to avoid unbalancing and vibration which may give rise to deterioration of the rotating parts.

For the same reason, do not keep a fan operating when one or several blades have been accidentally damaged. In case of vibration or motor shut-down due to electrical overload, check that the angle of the blades has not changed and is identical for each blade.

Basin - The air going through the cooling tower deposits a certain amount of dust/dirt which settles in the basin and causes the formation of a muddy deposit which must be regularly removed.

The frequency of this cleaning obviously depends on the quantity of dust contained in the air in the cooling tower. In general, however, cleaning once a year is enough.

In the case where, besides the air dust, the operating conditions cause additional materials to settle, more frequent cleaning will be required. Such additional material may enter the system either from the make-up water or by the cooling process.

Fanstack - The fanstack is subjected to vibratory forces inherent to the fan (they generally cannot be measured without instruments). It is necessary to check the tightness of the fanstack bolts at least every six months.

Fill - The causes of deterioration of the fill are generally of the following nature:

a. Those attributable to the quality of water.
b. Those attributable to deposits and water overloads, (i.e. ice)
c. Those attributable to high water concentrations (broken pipes or nozzles) resulting from a defect in the water distribution system.

As with the drift eliminators, keep the fill free of accumulations of debris.

Gear Reducer - Make daily and monthly oil checks. Inspect internal parts during seasonal oil change. Regular oil analyses should be made of the gearbox lubricating oil. Initially, an analysis should be made after any storage of the gearboxes and before putting into operation and approximately one month after initial operation. Due to the potential of over heating lubricating oil in gearboxes fitted with immersion heaters, regular analyses are particularly important in this case. The frequency of subsequent oil analyses should be based on the results of previous analyses in consultation with the lubricating oil supplier. Questions in this regard may also be referred to GEA.

Painting - Periodically clean and, if necessary, recoat all metal parts subject to corrosion.

Note: **Once during every shift it is advisable to make a general inspection of the tower.**

It is recommended that:
-basin water level be checked;
-gear box oil level be checked;
-locate and check any suspect noise or vibration

It is recommended that a detailed log book be kept for each cell. (To be supplied by purchaser)

The above checks, etc. are the minimum we consider necessary for trouble free operation.

If after installation, regular operation is delayed pending completion of plant construction or if there are long idle periods between operating cycles, it is necessary to start the motor\gearbox\fan group every week for a period of 5 minutes to bring all inner parts of gearbox and the ball bearings into contact with the lubricant. If the motor is not electrically connected, the rotation must be done manually.

Plume Abatement Components

Bundles – See section E

Louvers – See section E

Vacuum System – See Section E

Actuator – See Section E

MECHANICAL EQUIPMENT STORAGE

1) The cooling tower mechanical equipment has been installed and prepared for operation. If operation will be delayed beyond one month past completion of tower erection, steps must be taken to preserve the mechanical equipment, especially motors and gearboxes, by one of the two following recommended procedures.

   Intermittent operation - on a frequency of no less than once every two weeks, start and operate the fan units for at least five (5) hours at high speed. Pre-start inspections as described elsewhere should be conducted prior to each start. Motor heater power must be continuously maintained. Note that without the heating effect of warm water flowing over the tower the gearbox ambient will be the outside ambient. Reference must be made to the gearbox manufacturer's instructions regarding the correct selection of lubricating oil viscosity. This may require oil changes depending on ambient temperature variations. Alternatively, synthetic oils permit a wider range of temperatures and may eliminate or reduce the need to change oil. Please refer questions to GEA in this regard. On those gearboxes fitted with oil immersion heaters, power to the heater must be maintained during inoperation and secured when the gearbox is operated (typically through an interlock with the motor starting circuit).

   Storage - Motor heater power must be maintained at all times. A layer of grease must be applied and maintained to the gearbox output shaft a described elsewhere in this manual. To prevent internal water condensation due to temperature changes, remove the oil vent and install a riser pipe to an elevation slightly above the elevation of the gearbox output shaft.

Remove the plug on top of the gearbox case and completely fill the gearbox with lubricating oil. Reinstall the case plug and also plug the vent riser. Periodically check the level to insure the gearbox is completely flooded and add oil as necessary. On gearboxes fitted with oil immersion heaters, maintain power to the heater during periods of non operation.

III.3. TOWER TROUBLE TIPS

Trouble	Cause	Remedy
Motor will not start.	Power not available at motor terminals	1. Check power at starter. Correct any connections between the control apparatus and the motor. 2. Check starter contacts and control circuits. Reset overloads, close contacts, reset tripped switches, or replace failed control switches.
	Wrong Connections	Check motor and control connections against wiring diagrams.
	Low Voltage	Check nameplate voltage against power supply. Check voltage at motor terminals.
	Open circuit in motor winding	Check starter windings for open circuits.
	Motor or fan drive stuck	Disconnect motor from load and check motor and gear reducer for cause of problem.
	Rotor is defective	Look for broken bars or rings.
Unusual motor noise	Motor running single-phase	Stop motor and attempt to start it. Motor will not start if single-phased. Check wiring, controls, and motor.
	Motor leads connected incorrectly	Check motor connections against wiring diagram on motor.
	Ball bearings	Check lubrication. Replace bade bearings.
	Electrical imbalance	Check voltages and currents of all three lines, correct if required.
	Air gap not uniform	Check and correct bracket fits or bearings.
	Rotor unbalanced	Rebalance.
	Fan hitting guard	Reinstall or replace fan.
Motor runs hot	Motor overload, low voltage or unbalanced voltage	Check voltage and current of all three lines against nameplate values.
	Incorrect fan blade pitch	See Fan Service Manual.
	Wrong motor rpm	Check nameplate against power supply. Check rpm of motor and gear ratio.
	Bearings over greased	Remove grease reliefs. Run motor up to speed to purge excess grease.

Trouble	Cause	Remedy
Motor runs hot (cont'd)	Rotor rubs stator bore	If this is not due to poor machining, replace worn bearings.
	Wrong lubricant in bearings	Change to proper lubricant. See motor manufacturer's instruction.
	One phase open	Stop motor and attempt to start it. Motor will not start if single-phased. Check motor wiring controls and motors.
	Poor Ventilation	Clean motor and check ventilation openings. Allow ample ventilation.
	Winding fault	Check with ohmmeter.
	Bent motor shaft	Straighten or replace shaft.
	Insufficient grease	Remove plugs and regrease bearings.
	Deterioration of grease or foreign material in grease.	Flush bearings and relubricate.
	Bearings damaged	Replace bearings.
Motor does not come up to speed	Voltage too low at motor terminals because of line drop	Check transformer and setting of taps. Use higher voltage on transformer terminals or reduce loads. Increase wire size or reduce inertia.
	Broken rotor bars	Look for cracks near the rings. A new rotor may be required. Have motor service man check motor.
Wrong Rotation (motor).	Wrong sequence of phases	Change any two of the three motor leads.
Gear Reducer Noise	Gear Reducer bearings	If new, see if noise disappears after one week of operation. Drain, flush, and refill gear reducer. See Gear Reducer Service manual. If still noisy, replace bearings.
	Gears	Correct tooth engagement. Replace badly worn gears. Replace gears with imperfect tooth spacing or form.

Trouble	Cause	Remedy
Unusual fan drive	Loose bolts and cap screws	Tighten all bolts and cap screws on all mechanical equipment and supports.
	Unbalanced drive shaft or worn couplings	Make sure motor and gear reducer shafts are in proper alignment and "match marks" properly matched. Repair or replace worn couplings. Rebalance drive shaft by adding or removing weights from balancing cap screws. See Drive Shaft manual.
Unusual fan drive	Fan	Be sure blades have proper pitch and track. Make certain all blades are as far from the center of the fan as safety devices permit. All blades must be pitched the same. See Fan Service Manual. Clean off deposit build-up on blades.
	Worn Gear Reducer	Check fan and pinion shaft bearings end play. Replace bearings as necessary.
	Unbalanced Motor	Disconnect load and operate motor. If motor still vibrates, rebalance rotor.
	Bent Shaft	Check fan and pinion shafts with dial indicator. Replace if necessary.
Fan noise	Loose fan hub cover	Tighten hub cover fasteners.
	Blade rubbing inside of fan cylinder	Adjust cylinder to provide blade tip clearance.
	Loose bolts in blade clamps	Check and tighten if necessary.

III.4. EQUIPMENT STORAGE

MOTOR STORAGE

A. EQUIPMENT MUST BE KEPT CLEAN.

1. Store indoors.

2. Keep covered to eliminate airborne dust and dirt.

3. Cover openings for ventilation, conduit connections, etc., to prevent entry of rodents, snakes, birds, and insects, etc.

B. EQUIPMENT MUST BE KEPT DRY.

1. Store in a dry area.

2. Temperature swings should be minimal to prevent condensation.

3. Space heaters are recommended to prevent condensation. (Connect heaters to 120 VAC under temperature swing conditions.)

4. Treat unpainted flanges, shafts, and fittings with a rust inhibitor.

5. Check insulation resistance before putting motor into service.

C. KEEP BEARINGS LUBRICATED.

1. Once per month, rotate shaft several turns to distribute grease in bearings.

2. If unit has been stored more than one year, add grease before start-up.

GEAR BOX STORAGE

SHORT TERM STORAGE

(Dry heated indoor storage is recommended)

Each unit is tested and protected before leaving the factory for any reasonable storage condition or time. Units that are to be exposed to extreme temperature variations or to high relative humidity while being stored for extended lengths of time will require special care. See the recommendations for long term storage.

LONG TERM STORAGE

(Dry heated indoor storage is recommended)

Spray internal parts with a rust preventative oil that is soluble with lubricating oil or add a vapor phase rust inhibitor to the oil as recommended by its manufacturer. Protect all outside surfaces with a rust preventative oil. Place the unit in a vapor tight bag or container or seal all vent openings. All cooling tower drives are furnished with a vent plug located on the top of the unit. This vent can be sealed by applying duct tape around the base of the plug. After sealing the unit, store in a shipping crate.

INACTIVE DRIVES

Units that are operated seasonally, or used only as standby, should be protected by adding a vapor phase rust inhibitor to the oil in the amounts recommended by the manufacturer. The unit should be check every 3-4 months, more rust inhibitor added and any water that may have formed from condensation should be drained.

The following vapor phase rust inhibitors have been used and found satisfactory:

Shell Oil SIV 4165254
Daubert Chemical Company Motorator