MARLEY®

user manual

F400 Clearsky® cooling tower

OPERATION - MAINTENANCE

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READ AND UNDERSTAND THIS MANUAL PRIOR TO OPERATING OR SERVICING THIS PRODUCT.

contents

The following defined terms are used throughout this manual to bring attention to the presence of hazards of various risk levels, or to important information concerning the life of the product.

⚠ Warning

Indicates presence of a hazard which can cause severe personal injury, death or substantial property damage if ignored.

⚠ Caution

Indicates presence of a hazard which will or can cause personal injury or property damage if ignored.

Note

Indicates special instructions on installation, operation or maintenance which are important but not related to personal injury hazards.

Note

These instructions assist in obtaining efficient, long life from Marley counterflow cooling towers. Direct questions concerning cooling tower operation and maintenance to your Marley sales representative. Always include your tower serial number when requesting information or ordering parts. Look for this number on the serial number nameplate.

plume characteristics

Because of the evaporation that takes place in a cooling tower, the leaving airstream is saturated with water vapor. This plume of saturated air can be highly visible because it is usually warmer and contains considerably more moisture than the surrounding atmosphere. As it cools to reach equilibrium with the ambient air, its excess water vapor condenses because cold air is incapable of assimilating as much moisture (specific humidity) as warm air. This condensed plume of moisture becomes visible as fog.

The cooling of this plume also decreases its buoyancy—its ability to rise. In many cases, particularly in adverse wind conditions, cooling plumes will remain at very low levels until they dissipate, often reinforcing ground level fogging. This is unacceptable in the vicinity of airports and is of serious concern when the density and persistency affects road visibility. The density, persistency, and buoyancy of this visible plume is a function of the total amount of heat extracted from the water by evaporation, the temperature at which the heat is extracted and the temperature of the ambient atmospheric air. The greater the difference between the temperature of the warm exhaust air and the cool ambient air, the more visible the plume.

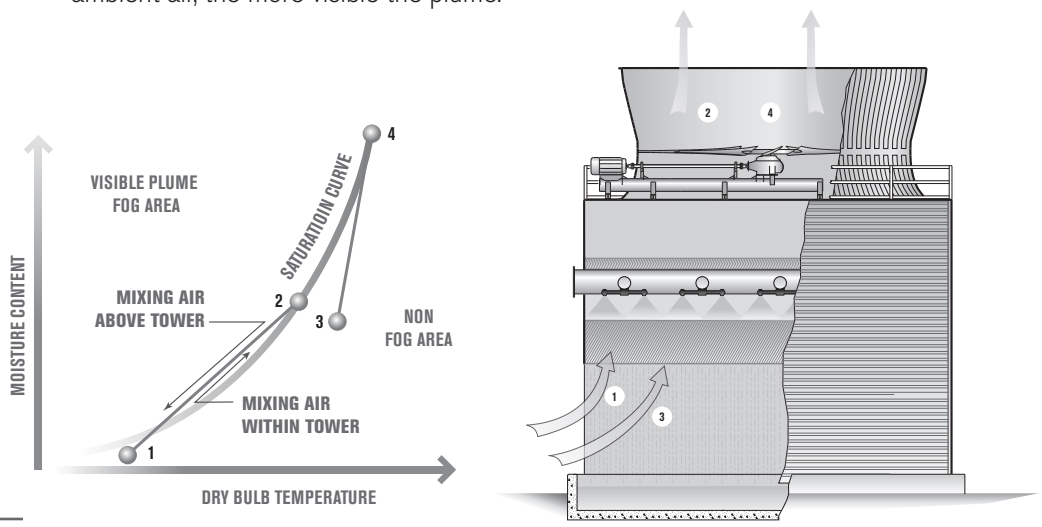


Figure 1

Visible plumes are typically much more dense and persistent in the wintertime than summer. This is shown graphically in Figure 1 which relates the characteristics of the plume to the saturation curve of a psychrometric chart. In winter operation, air enters the tower at condition 1 and leaves saturated at condition 2. On leaving the tower, the air reaches equilibrium with the ambient air along line 2–1. In doing so, it remains in the supersaturated (fog) region of the chart for a considerable time. Conversely, summer air enters the tower at condition 3, and exits saturated at condition 4. Returning to ambient conditions along line 4–3, the leaving airstream is never within the fog region. This classifies the plume visibility as wispy and short-lived, often not persisting beyond a few meters above the fan cylinder. Although higher heat loads can increase the persistency of summertime plumes, they never reach the density of those that form in cooler seasons.

plume characteristics

Marley ClearSky provide a means by which the plume leaving the tower can be made less visible, or more buoyant, or both resulting in reduced ground fogging. This is done by reducing the actual grains of moisture in the plenum airstream and at the same time producing a stream of heated dry air that is mixed with the tower's primary saturated airstream prior to its exit from the tower. This results in desaturation of the plume to the point where it does not cross into the fog region on its way back to ambient atmospheric air conditions. In other words, little or no condensation will occur. Visibility reduction is explained graphically in the Figure 2 ClearSky psychrometric diagram. The primary airstream leaves the cooling tower's wet section (fill) at condition 1 and it then passes through the ClearSky heat exchanger where a secondary airstream enters the dry side of the ClearSky heat exchanger, cooling the plume airstream and condensing a portion of the moisture moving the airstream condition along the saturation line to condition 2. The dry airstream gains heat but no moisture content and leaves at condition 3. These two airstreams mix together along line 3–2 exiting the tower at condition 4. Returning to atmospheric conditions along line 4–5, the plume is therefore neither dense nor persistent. Plume characteristics depend upon the application of the ClearSky heat exchanger modules to the cooling tower. In many cases, the plume can be made to become invisible within one or two fan diameters above the top of the tower fan cylinder.

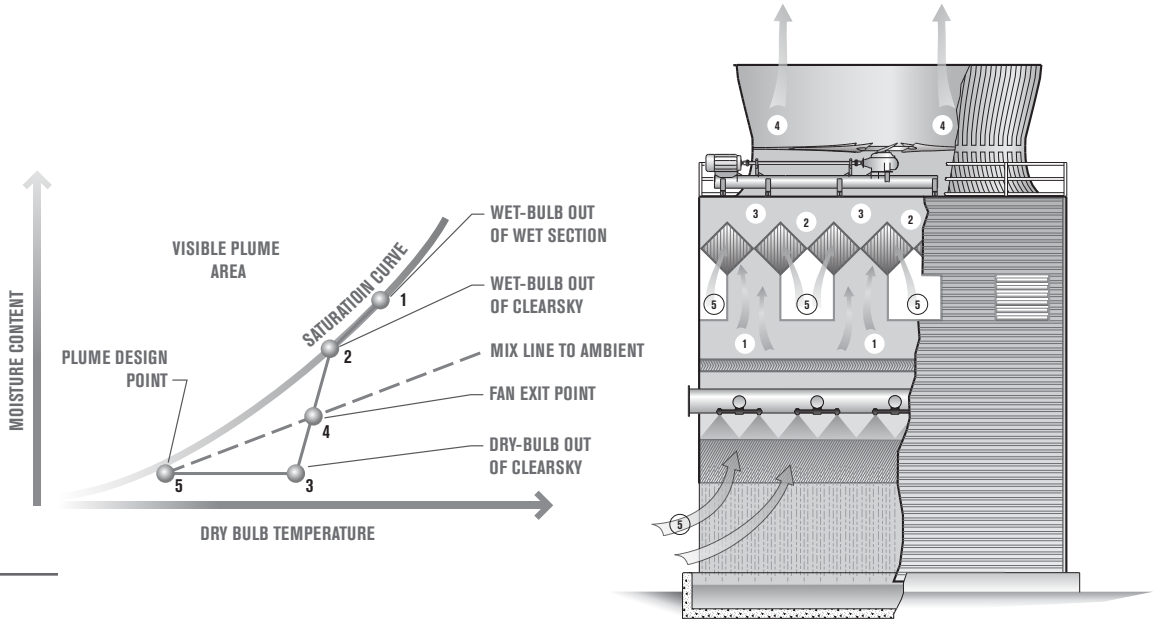


Figure 2

operation

Before Startup

⚠ Warning

Microorganisms including Legionella bacteria can exist in premise plumbing including cooling towers. The development of an effective water management plan (WMP) and implementation of maintenance procedures are essential to prevent the presence, dissemination and amplification of Legionella bacteria and other waterborne contaminants throughout premise plumbing. Before operating the cooling tower, the water management plan and maintenance procedures must be in place and regularly practiced.

1–Consult a knowledgeable water treatment professional to clean and treat your new cooling tower prior to startup. Cooling towers must be cleaned and disinfected regularly in accordance with ASHRAE Standard 188 and Guideline 12.

2–Do NOT attempt any service unless the fan motor is locked out.

Note

When starting in freezing weather, follow procedures outlined in Freezing Weather Operation.

INSPECTION–It is imperative that all operating assemblies be inspected before they are placed in operation. The following is a list of components to be checked before starting the tower:

1–Check driveshaft alignment. Realign if necessary. See the Drive Shaft User Manual.
2–Check tightness of bolts in fan cylinder joints.
3–Check tightness of the following bolted joints in the fan and drive assemblies:
   a–Fan hub clamp bolts. See the Fan User Manual for correct torque setting).
   b–Fan hub cover bolts.
   c–Geareducer® and motor mounting bolts.
   d–Driveshaft coupling and guard bolts.
4–Check Geareducer oil for sludge or water by draining off and testing a sample as outlined in the Geareducer User Manual. Check Geareducer oil level at "oil level" mark on the side of the case. Add oil as required. The oil level placard must be adjusted so that its "full" mark is at the same elevation as the "full" mark on the side of the Geareducer case. Check oil lines to be sure there are no leaks. See the Geareducer User Manual for oil filling procedure and list of recommended lubricants.
5–Rotate fan by hand to be sure of free rotation and ample tip clearance. See the Fan User Manual.
6–Check motor insulation with a megohm meter. Refer to the Maintenance Section of the Marley **"Fan Motor"** User Manual.

7–Lubricate the motor according to motor manufacturer's instructions.

8–Test run each fan separately for a short time. Check for excessive vibration or unusual noise. If either is present, see **Troubleshooting Guide** on pages 18 and 19 of this manual. Fan must rotate clockwise when viewed from above. Recheck Geareducer oil level.

9–Check functioning of make-up water supply.

10–Make sure the blowdown will carry the proper amount of water.

11–Check dry damper linkage to be sure linkage is properly functioning. Actuate dry dampers to make sure they open and close.

12–Check dry duct vent doors to see that linkage is properly functioning. In cold weather if possible inspect doors for snow and ice that may freeze doors shut. Tower may need to operate with heat load to melt snow and ice prior to operating vent doors. Actuate dry duct vent doors to make sure they open and close.

Starting Procedure

WATER SYSTEM–Fill the cold water collection basin and circulating water system until the operating water level is reached. See **Operation**. Prime and start the circulating water pumps. Increase the flow of circulating water gradually to design water flow rate to avoid water hammer which could damage the distribution piping system.

Note

Clean the sump screens several times during the first weeks of operation. After this, clean sump screens weekly.

Note

When starting in cold weather, follow procedures outlined in Cold Weather Operation.

FAN START–After 30 minutes of operating time to permit Geareducer oil to come up to operating temperature, check motor load with watt meter, or take operating volt and ampere readings and calculate motor hp. Refer to the Fan User Manual for instructions. Pitch fans to pull correct contract horsepower when circulating design water rate at design hot water temperature.

operation

Operation

⚠ **Caution**

Entering water temperature in excess of 125°F may result in fill deformation.

TOWER PERFORMANCE–Keep the cooling tower clean and water distribution uniform to obtain continued maximum cooling capacity.

The capacity of a cooling tower to cool water to a given cold water temperature varies with the wet-bulb temperature and the heat load applied to the cooling tower. As the wet-bulb temperature drops, the cold water temperature also drops. However, the cold water temperature does not drop linearly with the wet-bulb temperature.

A cooling tower will not control heat load. The flow rate of water circulated through the cooling tower will determine the temperature range of cooling in conjunction with a given heat load. The hot water and cold water temperatures will increase with higher heat loads.

ClearSky Plume Abatement System

ClearSky towers have the unique ability to vary operation between **Maximum Thermal Performance Mode** and **Maximum Plume Abatement Mode**. This system variation is achieved by manipulating motor operated control linkages to alter the air paths between heated saturated air or dry ambient air. Mechanically actuated vent doors located in a horizontal plane just above the mist eliminators at the base of dry air ducts can be opened to permit passage of heated saturated air from the wet section of the cooling tower into dry path air ducts. Dry dampers mounted on the tower's exterior can regulate the amount of dry ambient air passing through the dry ducts and then heated in the ClearSky heat transfer media packs before being exhausted through the fan cylinder. By closing the dry dampers and opening the vent doors, heated saturated air is permitted to pass through the ClearSky media passages designed for dry air. Thus maximum heated saturated air flow through the fill is achieved producing maximum cooling.

MAXIMUM THERMAL PERFORMANCE MODE–Position the dry dampers in the closed position and position the vent doors in the open position.

MAXIMUM PLUME ABATEMENT MODE–Position the vent doors in the closed position and position the dry dampers in the open position.

⚠ Caution

In transitioning from maximum thermal performance to maximum plume abatement, the hot and cold water temperatures will rise. Care must be exercised to ensure that the water temperatures do not rise above 125°F or a lower limit defined by the user's process.

PARTIAL PLUME ABATEMENT MODE–When managing maximum water temperatures and reducing plume, the tower may be operated in partial plume abatement mode. Position the vent doors in the closed position. Initially place the dry dampers in the closed position and let the water temperatures stabilize. If the water temperatures are too high, then open the vent doors for maximum cooling. If the water temperatures are below maximum acceptable temperatures, adjust the dry dampers incrementally open until either the plume is acceptable or until maximum water temperatures are reached.

Note

Reference ClearSky Operation Logic Diagram and Notes on pages 10 and 11.

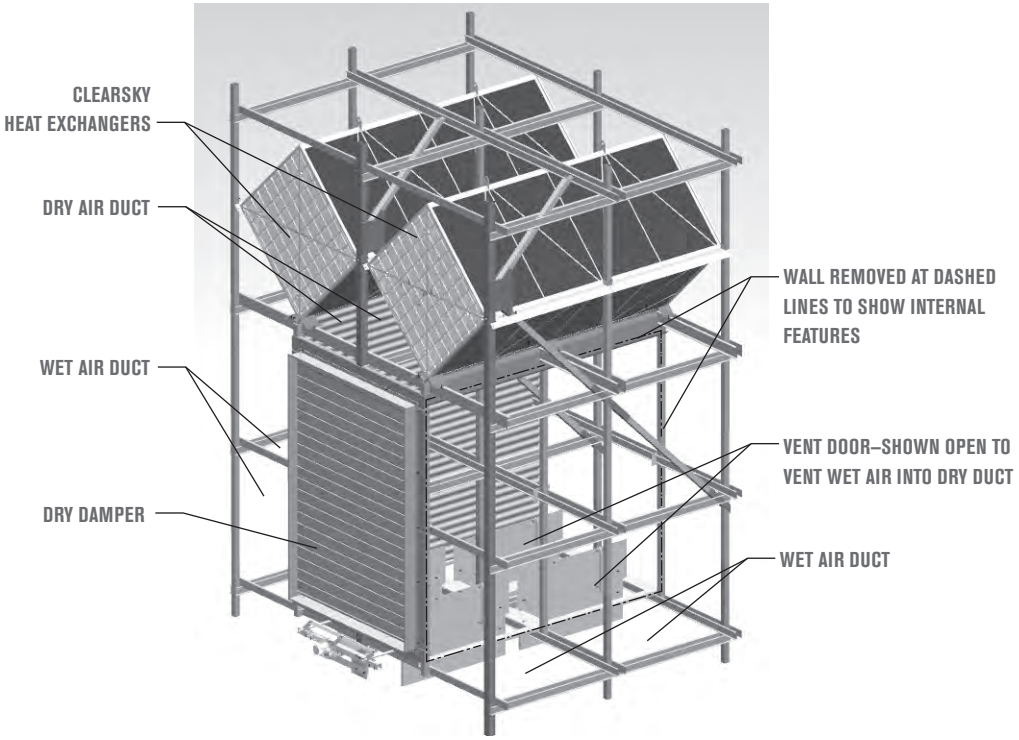


Figure 3

Partial section showing the ClearSky plume abatement components

HOT WATER DISTRIBUTION SYSTEM–Maintain uniform water distribution at the nozzles (uniform spray cone). The amount of water circulated should approximate the contract requirements and the nozzle pressure should be kept constant. Lower pressures may indicate excessive losses in the piping system and/or insufficient pump capacity; greater pressures might indicate clogged nozzles and/or overpumping. If a greatly reduced water flow rate is desired, it may be advisable to change nozzle sizes

to obtain the desired pressure and maintain proper water distribution. An SPX Cooling Technologies engineer can advise minimum and maximum flow rates for even distribution.

COLD WATER COLLECTION BASIN–A suitable depth must be maintained to keep the pumps from pulling air into the line. The amount of "make-up" water required to keep the water in the collection basin at the required depth depends upon the "evaporation loss" and "blowdown" .

FAN DRIVE–When using two-speed motors, allow a time delay of 20 seconds minimum after de-energizing the high-speed winding and before energizing the low-speed winding. Tremendous stresses are placed on driven machinery and motors unless the motors are allowed to slow to low-speed RPM or less before the low-speed winding is energized.

FREEZING WEATHER OPERATION–During periods of cold temperature operation, 35°F to 40°F or below, ice will form on the relatively dry parts of the cooling tower that are in contact with the incoming air. Primarily, this includes the air inlet and adjacent structural framing. Your understanding of cold weather operation will be enhanced if you read **"Cooling Towers and Freezing Weather"** *Marley Technical Report H-003.*

Ice forming characteristics on any given cooling tower will vary, depending on velocity and direction of wind, circulating water rate, and heat load. Excessive ice formation may be controlled by regulating air and water flow through the tower by one or more of the following procedures:

1–Shut the fan down. This reduces the cooling air rate to a minimum and increases the quantity of warm water at the air inlet to a maximum. However, normal "fan off" operation causes reverse air flow by aspiration and may cause water blowout and therefore must be done with caution and monitoring. For automatic operation, a timer switch can be provided to shut the fan down for a few minutes each hour.

2–When a cooling tower has two-speed motors, operate the fans at half speed forward. This reduces the cooling air rate (heat transfer) and increases the quantity of warm water at the air inlet. *Not recommended for plume control.*

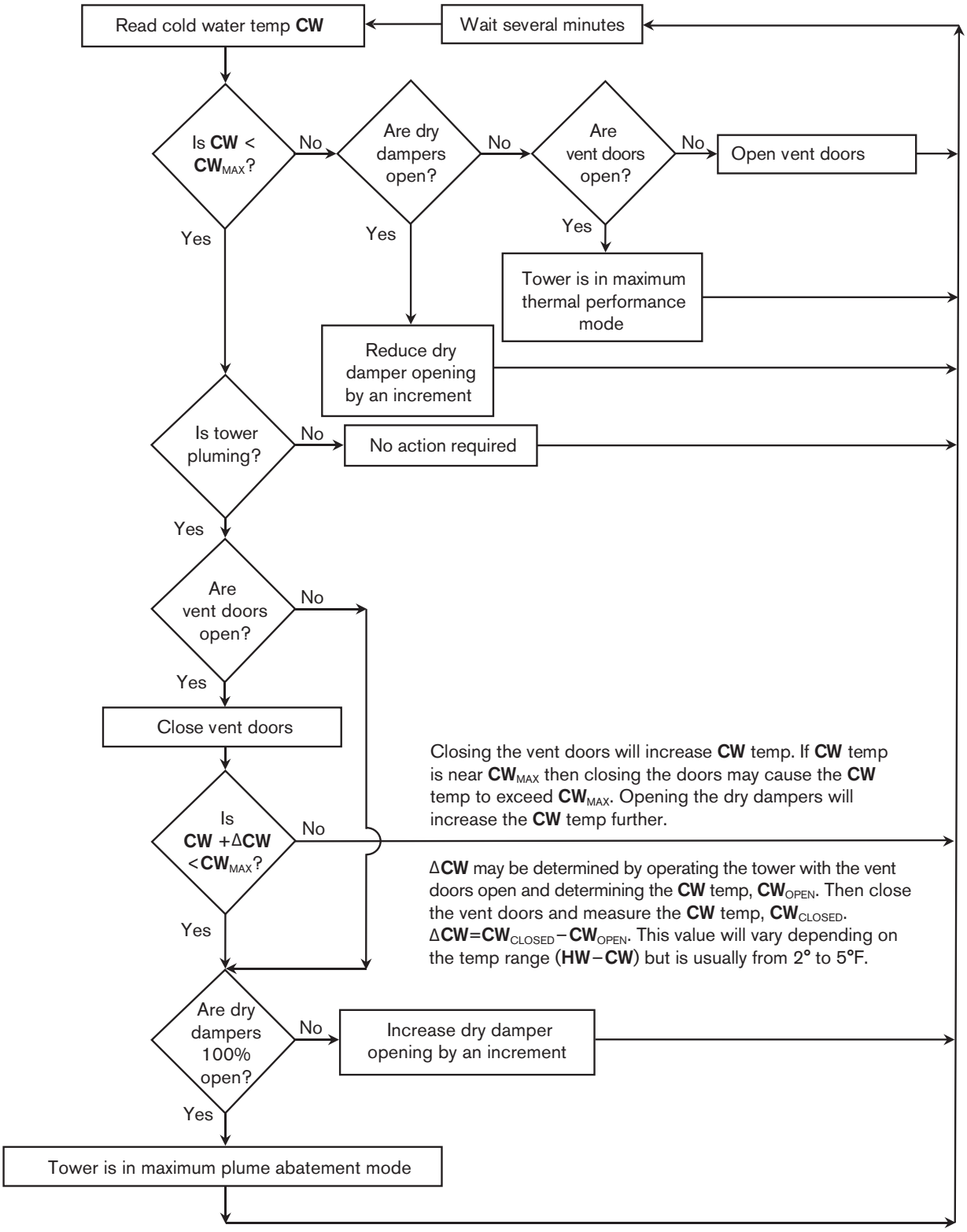
3–With no heat load on the circulating water, icing cannot be controlled. Towers *must not* be operated with reduced water rate and/or no heat load during freezing weather. If a bypass directly into the cold water basin is used, all water must be bypassed.

⚠ Caution

Reverse operation of fans is not recommended . See "Fan Drive" for fan speed change precautions.

INTERMITTENT OPERATION–When the unit is operated intermittently during winter weather, it is necessary that the water be drained from the tower piping to insure protection against freezing and possible rupture.

ClearSky Operation Logic Diagram



ClearSky Operation Logic Diagram Notes

1–Assumes maximum cold water (CW_{MAX}) temperature has priority over plume abatement.

2–Assumes fans are operating at full speed.

3–Assumes vent doors are either all open or all closed. Further operational flexibility could be gained by only opening or closing some of the vent doors.

4–Assumes dry dampers are closed when vent doors are open.

5–CW_{MAX} is the maximum allowable cold water temperature established by the user. Material temperature limits or process limits may influence this value.

6–ΔCW is a nominal rise in cold water temperature due to closing vent doors from their open position. Dry dampers are assumed closed before and after the vent doors are closed.

7–Dry damper opening increments may need to be empirically determined as the actuator position is not linear with air flow.

8–Maximum thermal performance mode means that no more damper or vent options are available to increase thermal performance (to lower the cold water temperature).

9–Maximum plume abatement mode means that no more damper or vent options are available to increase plume abatement.

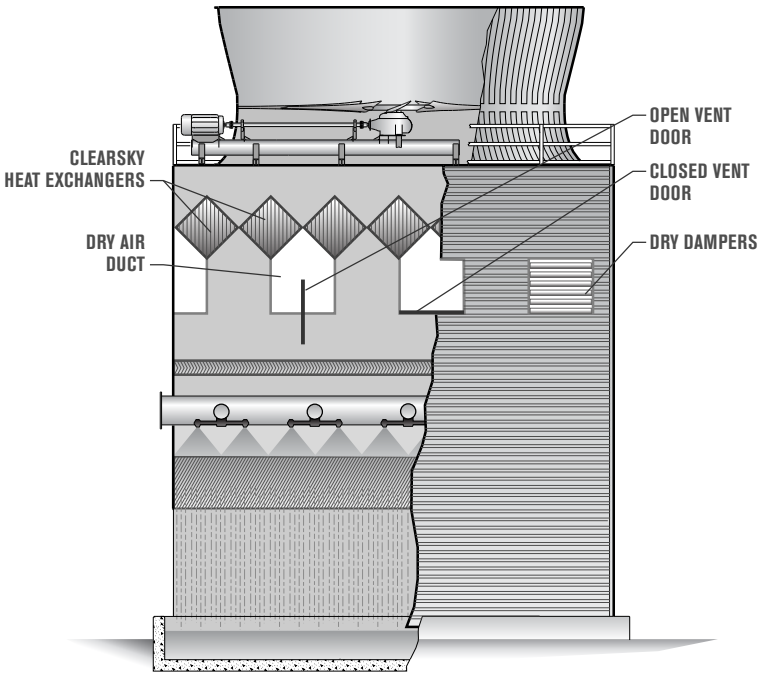


Figure 4

maintenance

Tower Maintenance

⚠ **Warning**

Always shut off electrical power to the tower fan motor prior to performing any inspections that may involve physical contact with the mechanical or electrical equipment in or on the tower. Lock out and tag out any electrical switches to prevent others from turning the power back on. Service personnel must wear proper personal protective clothing and equipment.

Well-maintained equipment gives the best operating results and the least maintenance cost. SPX recommends setting up a regular inspection schedule to insure effective, safe operation of the cooling tower. Use the schedule on page 17 to obtain continuously good performance with the least tower maintenance. See **Cooling Tower Inspection Check List** in this manual. Keep a continuous lubrication and maintenance record for each cooling tower.

HOT WATER DISTRIBUTION SYSTEM–Keep the circulating water and distribution system (piping and nozzles) clean and free of dirt, algae, and scale. Algae and scale may clog nozzles, eliminators, fill, and piping, and may collect on the equipment served thus reducing its performance.

An access hatch in the fan deck with ladder to an intermediate platform provides means for inspection of the plenum area above the eliminators. Removal of an access hatch at the plenum level allows access to the spray chamber for inspection and maintenance of the nozzles and top of fill. Provide surface protection before walking on the fill.

DRIFT ELIMINATORS–Eliminators should be kept clean.

⚠ **Warning**

Do not walk or step on the eliminators without planking and safety harness.

COLD WATER COLLECTION BASIN (supplied by others)–Inspect collection basin occasionally for leaks and repair if necessary. Keep cold water outlets clean and free of debris. Makeup and circulating water controls must operate freely and maintain the desired water quantity in the system.

DRIVESHAFT–Check drive shaft alignment and condition of couplings every six months. See the Drive Shaft User Manual for correcting misalignment, balancing, or replacing parts.

FAN MOTOR–Lubricate and maintain each electric motor in accordance with the manufacturer's instructions. If repair work is necessary, contact the nearest representative of the motor manufacturer. See Warranty Section of the Marley "**Fan Motor"** User Manual. Fan motors with sealed bearings do not require lubrication maintenance.

maintenance

FAN–Inspect fan blade surfaces every six months. For detailed maintenance information, refer to the Fan User Manual.

GEAREDUCER–Make weekly and monthly oil checks. Inspect internal parts during seasonal oil change. Refer to the Geareducer User Manual for detailed maintenance instructions.

DRY DAMPERS–Inspect linkages, adjust and lubricate as needed.

VENT DOORS–Inspect linkages and bearings, adjust and lubricate as needed.

PAINTING–Periodically clean and, if necessary, recoat all metal parts subject to corrosion.

Water Quality and Blowdown

BLOWDOWN–Blowdown, or bleed-off, is the continuous removal of a portion of the water from the circulating system. Blowdown is used to prevent the dissolved solids from concentrating to the point where they will form scale. The amount of blowdown required depends upon the cooling range (the difference between the hot and cold water temperatures), the composition of the make-up water (water added to the system to compensate for losses by blowdown, evaporation and drift). and the amount of condensed water returned from the ClearSky heat exchanger modules. The following table shows an approximate amount of blowdown required to maintain different concentrations with various cooling ranges—these numbers are reduced by the % of condensed water at a given weather condition:

BLOWDOWN–% OF CIRCULATING RATE

Cooling Range	Number of Concentrations						
	1.5X	2.0X	2.5X	3.0X	4.0X	5.0X	6.0X
3°C	.78	.3	.25	.18	.11	.08	.06
6°C	1.58	.7	.51	.38	.25	.18	.14
9°C	2.38	1.1	.78	.58	.38	.28	.22
12°C	3.18	1.5	1.05	.78	.51	.38	.30
14°C	3.98	1.9	1.32	.98	.64	.48	.38
Multipliers are based on drift of 0.02% of the circulating water rate							

EXAMPLE: 7000 gpm circulating rate, 15° cooling range. To maintain 4 concentrations, the required blowdown is .38% or .0038 times 7000 gpm which is 26.6 gpm.

maintenance

If tower is operated at 4 concentrations, circulating water will contain four times as much dissolved solid as the make-up water, providing none of the solids form scale or are otherwise removed from the system.

The blowdown quantity is normally and most easily achieved using a bleed value activated by a measurement of the water's dissolved solids. In this way, no exact calculation of blowdown gpm is required on an ongoing basis.

CHEMICAL TREATMENT– Chemical treatment is required to control biological growth in the cooling tower fill, basins, and piping. In most cases chemical treatment of the circulating water is not required if adequate blowdown is maintained. In most cases, however, chemical treatment is required to prevent scale formation and corrosion. Sulfuric acid or one of the polyphosphates is most generally used to control calcium carbonate scale. Various proprietary materials containing chromates, phosphates or other compounds are available for corrosion control. When water treatment chemicals are required, the services of reliable water treating companies should be obtained.

Biofilm, a gelatinous organic growth, and algae, a green moss, may grow in the cooling tower or heat exchangers. Their presence can interfere with cooling efficiencies. Proprietary compounds are available from water treating companies for the control of slime and/or algae; however, compounds which contain copper are not recommended. Chlorine and chlorine containing compounds are effective algaecides and slimicides. If used, chlorine should be added as intermittent (or shock) treatment only as frequently as needed to control the slime and algae. Chlorine and chlorine containing compounds should be added carefully since very high levels of chlorine may occur at or near the point of entry into the circulating water system.

FOAMING–Heavy foaming sometimes occurs when a new tower is put into operation. This type of foaming generally subsides after a relatively short period of operation. Persistent foaming can be caused by the concentrations of certain combinations of dissolved solids or by contamination of the circulating water with foam-causing compounds. This type of foaming can sometimes be minimized by increasing the blowdown, but in some cases foam depressant chemicals must be added to the system. Foam depressants are available from a number of chemical companies.

MAINTENANCE OF FILL PERFORMANCE

⚠ **Caution**

Owner must keep water clean by treatment, screening, or filtering to avoid the possibility of fill clogging and loss of thermal performance.

maintenance

Potential Causes of Fill Clogging:

- Suspended materials—Debris, etc.
- Scale—Can be sulfates, silicates, carbonates, or oxides. Scaling effects can be accentuated by suspended solids.
- Algae and/or Biofilm—Consult a qualified water treatment professional.

Possible Sources of Scale:

- Calcium Sulfate—From make-up and sulfates produced by sulfuric acid for pH adjustment. Calcium sulfate should be kept below 1000 ppm expressed as $CaCO_3$
- Calcium Carbonate—Generally will not form scale in the cooling tower if carbonate scaling does not occur in the condenser.
- Exceptions: If make-up water contains surplus free carbon dioxide, scaling may be inhibited in the condenser, but may occur in the tower fill because of CO_2 stripping.
- Silicates and Oxides—Silica scale is virtually impossible to remove. Silica scale is unlikely if SiO_2 is held below 150 ppm. Oxides, such as iron oxide, can coat all parts of the system if soluble iron is present in concentrations above 0.5 ppm. Iron oxides do not usually develop into thick scales but can accentuate the development of other scales.

MAINTENANCE OF CLEARSKY PVC HEAT EXCHANGERS

Fouling

- Dust may accumulate in the dry air ducts over time causing reduced heat transfer.

⚠ **Caution**

Do not use high pressure washing equipment on ClearSky PVC heat exchangers.

- Low pressure washing from a municipal or similar water supply system using a hose with a spray nozzle on a shower setting is recommended. Do not spray a jet stream directly on the PVC ClearSky heat exchangers. Spray water at the top of the ClearSky heat exchangers.

Leaks

- Water should not be allowed to accumulate in the dry air ducts (except when cleaning). Evaporation of water in the dry ducts will reduce plume abatement. Furthermore, in cold climates ice accumulation may cause damage.
- Leaks at casing and or flashing should be resealed.
- Leaks in the PVC heat exchange tubes may be sealed with an adhesive. PVC cement is not recommended because it may soften the plastic. In the event that the source of the leak can not be identified, the wet path of that tube should be plugged. A closed cell flexible foam that can be inserted and removed is recommended.

maintenance

Spare Parts

SPX Cooling Technologies manufactures and inventories cooling tower replacement parts. Typical lead time is 10 working days. Contact your Marley representative for emergency service.

Owners should consider maintaining an inventory of critical mechanical components, such as a fan assembly, gear drive and driveshaft to avoid emergency shutdown of cooling tower operations. Be sure to furnish the cooling tower serial number when ordering parts.

Seasonal Shutdown Instructions

Tower–Drain all tower piping.

During shutdown, follow recommendations in the **Cooling Tower Inspection and Maintenance** section of this manual before attempting repairs. Apply protective coating as required to all metal parts. Particular attention should be given to mechanical equipment supports, drive shaft and drive shaft guards.

Mechanical Equipment

Geareducer – Downtime for 3 months or less

1–Each month, drain water condensate from the lowest point of the Geareducer and its oil system. Check oil level and add oil if necessary. Operate to coat all interior surfaces with oil.
2–At start-up, drain water condensate and check oil level. Add oil if necessary. Refer to the Geareducer User Manual for maintenance and lubrication instructions.

Geareducer – Downtime for 3 months or more

1–If the fan motors have space heaters, operate mechanical equipment one hour each month.
2–If the fan motors do not have space heaters, operate mechanical equipment one hour each week.
3–At startup, operate mechanical equipment one hour or until oil is warm, then shut the equipment down. Drain the oil and refill. Refer to the Geareducer User Manual for instruction on changing oil. Refer to the Downtime Instructions User Manual for downtime exceeding six months.

Fan Motors

1–Do not start motor without determining that there will be no interference with free rotation of the fan drive.
2–Refer to the “Fan Motor” User Manual for additional information.

3–If shutdown period is longer than seasonal, contact your Marley sales representative for additional information.

ClearSky Plume Abatement System Close dry dampers to prevent foreign objects from entering the dry ducts.

Cooling Tower Inspection and Maintenance:

⚠ **Warning**

Microorganisms including Legionella bacteria can exist in premise plumbing including cooling towers. The development of an effective water management plan (WMP) and implementation of maintenance procedures are essential to prevent the presence, dissemination and amplification of Legionella bacteria and other waterborne contaminants throughout premise plumbing. Before operating the cooling tower, the water management plan and maintenance procedures must be in place and regularly practiced.

In addition, the following steps are recommended:

Do NOT attempt any service unless the fan motor is locked out.

- Consult a knowledgeable water treatment professional to clean and treat your cooling tower prior to startup. See **Before Startup** section of this manual.
- Cooling towers must be cleaned and disinfected regularly in accordance with ASHRAE Standard 188 and Guideline 12.
- Workers performing decontamination procedures must wear personal protective equipment (PPE) as directed by their facility safety officer.
- Cooling towers must be visually inspected regularly to assess signs of bacterial growth, appearance of debris and scale on drift eliminators and general operating conditions. Refer to ASHRAE Standard 188 and Guideline 12 for specific frequency recommendations.
- Replace worn or damaged components.

To minimize the presence of waterborne microorganisms, including Legionella, follow the water management plan for your facility, perform regularly scheduled cooling tower inspections and maintenance, and enlist the services of water treatment professionals.

For additional technical support, contact your Marley sales representative. For help identifying the sales representative in your area, visit spxcooling.com/replocator.

References:

ashrae.org. Search “ASHRAE Standard 188” and “ASHRAE Guideline 12.”

cdc.gov. Search “Water Management Program.”

troubleshooting

Trouble	Cause	Remedy
Motor will not start	Power not available at motor terminals	Check power at starter. Correct any bad connections between the control apparatus and the motor.
		Check starter contacts and control circuit. Reset overloads, close contacts, reset tripped switches or replace failed control switches.
		If power is not on all leads at starter, make sure overload and short circuit devices are in proper condition.
	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 stator windings for open circuits.
	Fan drive stuck	Disconnect motor from load and check motor and Geareducer for cause of problem.
	Rotor 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.
	Bad bearings	Check lubrication. Replace bad bearings.
	Electrical unbalance	Check voltages and currents of all three lines. Correct if required.
	Air gap not uniform	Check and correct bracket fits or bearing.
	Rotor unbalance	Rebalance.
	Cooling fan hitting end bell-guard	Reinstall or replace fan
Motor runs hot	Wrong voltage or unbalanced voltage	Check voltage and current of all three lines against nameplate values.
	Overload	Check fan blade pitch. See Fan User Manual. Check for drag in fan drivetrain as from damaged bearings.
	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 excessive grease. Does not apply to motors with sealed bearings.
	Wrong lubrication in bearings	Change to proper lubricant. See motor manufacturer's instructions.
	One phase open	Stop motor and attempt to start it. Motor will not start if single phased. Check wiring controls and motor
	Poor ventilation	Clean motor and check ventilation openings. Allow ample ventilation around motor.
	Winding fault	Check with Ohmmeter.
	Bent motor shaft	Straighten or replace shaft.
	Insufficient grease	Remove plugs and regrease bearings. Does not apply to motors with sealed bearings.
	Too frequent starting or speed changes	Limit cumulative acceleration time to a total of 30 seconds per hour. Set on/off or speed change set-points farther apart. Consider installing a Marley VFD for fine temperature control.
	Deterioration of grease or foreign material in grease	Flush bearings and relubricate. Does not apply to motors with sealed bearings.
	Bearings damaged	Replace bearings.

troubleshooting

Trouble	Cause	Remedy
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 person check motor.
Wrong motor rotation	Wrong sequence of phases	Switch any two of the three motor leads.
Geareducer noise	Geareducer bearings	If new, see if noise disappears after one week of operation. Drain, flush and refill Geareducer oil. See Geareducer User Manual. If still noisy, replace.
	Gears	Correct tooth engagement. Replace badly worn gears. Replace gears with broken or damaged teeth
Unusual fan drive vibration	Loose bolts and cap screws	Tighten all bolts and cap screws on all mechanical equipment and supports.
	Unbalanced driveshaft or worn couplings	Make sure motor and Geareducer shafts are in proper alignment and “match marks” properly matched. Repair or replace worn couplings. Rebalance driveshaft by adding of removing weights from balancing cap screws. See Driveshaft User Manual.
	Fan	Make certain all blades are as far from center of fan as safety devices permit. All blades must be pitched the same. See Fan User Manual. Clean off deposit build-up on blades
	Worn Geareducer bearings	Check fan and pinion shaft endplay. Replace bearings as necessary.
	Unbalanced motor	Disconnect load and operate motor. If motor still vibrates, rebalance motor.
	Bent Geareducer shaft	Check fan and pinion shaft with dial indicator. Replace if necessary.
Fan noise	Blade rubbing inside of fan cylinder	Adjust cylinder to provide blade tip clearance.
	Loose bolts in blade clamps	Check and tighten if necessary.
Insufficient Cold Water	Tower operating in plume abatement mode	See ClearSky Operation Logic diagram on page 10.
Plume	Insufficient dry air	Close vent doors and incrementally open dry dampers. See ClearSky Operation Logic diagram on page 10.
	Duty more difficult than design	Tower will plume. Configure for maximum plume mode. See ClearSky Operation Logic diagram on page 10.

SAFETY–The F400 Clearsky cooling tower has been designed to provide a safe working environment while either operating or shut down. The ultimate responsibility for safety rests with the operator and owner. When water flow to the tower is shut off or when portions of the tower require maintenance, temporary safety barricades may be required around openings and fall protection equipment should be utilized where appropriate for compliance with OSHA regulations, standards and good safety practices.

Routine periodic maintenance must be performed on all personnel access and material handling accessories in accordance with the following schedule:

	Ladders, Stairways, Walkways, Handrails, Covers, Decks and Access Doors	Davits, Derricks, and Hoists
Inspect for General Condition	Semi-annually	Semi-annually
Inspect and Repair for Safe Use	Yearly	
Inspect and Repair Before Each Use		As Required

inspection checklist

Date Inspected _____ Inspected By _____

Owner _____ Location _____

Owner's Tower Designation _____

Tower Manufacturer _____ Model No. _____ Serial No. _____

Process Served by Tower _____ Operation: Continuous ❑ Intermittent ❑ Seasonal ❑

Design Conditions gpm _____ HW _____ °F CW _____ °F WB _____ °F

Number of Fan Cells _____

Condition: 1—Good 2—Keep an eye on it 3—Needs immediate attention

	1	2	3	Comments
Structure				
Casing Material _____				
Structural Material _____				
Fan Deck Material _____				
Stairway? _____ Material _____				
Ladder? _____ Material _____				
Handrails? _____ Material _____				
Interior Walkway? _____ Material _____				
Cold Water Basin Material _____				
Water System				
Distribution System _____				
Header Material _____				
Manifold Material _____				
Branch Arms _____				
Nozzles – Orifice Diameter _____"				
Heat Transfer System				
Fill _____				
Eliminators _____				
Inlet Face of Fill _____				

Use this space to list specific items needing attention: _____

Condition: 1—Good 2—Keep an eye on it 3—Needs immediate attention

Mechanical Equipment	1	2	3	Comments
Gear Drive Units				
Manufacturer _____ Model _____ Ratio _____				
Oil Level: Full ❑ Add Immediately ❑ Low, check again soon ❑				
Oil Condition: Good ❑ Contains Water ❑ Contains Metal ❑ Contains Sludge ❑				
Oil Used – Type _____				
Seals _____				
Backlash _____				
Fan Shaft Endplay _____				
Any Unusual Noises? No ❑ Yes ❑ Action Required: _____				
Drive Shafts				
Manufacturer _____ Material _____				
Fans				
Manufacturer _____ Fixed Pitch ❑ Adjustable Pitch ❑				
Diameter _____ Number of Blades _____				
Blade Material _____				
Hub Material _____				
Hub Cover Material _____				
Blade Assembly Hardware _____				
Tip Clearance _____"min. _____"max.				
Vibration Level _____				
Fan Cylinder Height _____				
Mech.Eqpt. Support Mat'l _____				
Oil Fill and Drain Lines _____				
Oil Level Sight Glass _____				
Vibration Limit Switches _____				
Makeup Valves _____				
Other Components _____				
Motor Manufacturer _____				
Name Plate Data: hp _____ RPM _____ Phase _____ Hz _____ Volts _____				
F.L. Amps _____ Frame _____ SF _____ Special Info. _____				
Last Lubrication – Date _____ _____				
Grease Used – Type _____				
Any Unusual Noise? No ❑ Yes ❑ Action Required _____				
Any Unusual Vibration? No ❑ Yes ❑ Action Required _____				
Any Unusual Heat Build-up? No ❑ Yes ❑ Action Required _____				

inspection checklist

Actuators – Dry Dampers

Manufacturer _____ Model _____ Ratio _____

Motor Manufacturer _____

Name Plate Data: _____ hp_____ RPM_____ Phase_____ Cycle_____ Volts_____

F.L. Amps _____ Frame_____ S.F._____ Special Info._____

Last Lubrication–Date _____

Grease Used–Type _____

Any Unusual Noise? No ❑ Yes ❑ Action Required _____

Any Unusual Vibration? No ❑ Yes ❑ Action Required _____

Any Unusual Heat Build-up? No ❑ Yes ❑ Action Required _____

Actuators – Vent Doors

Manufacturer _____ Model _____ Ratio _____

Motor Manufacturer _____

Name Plate Data: _____ hp_____ RPM_____ Phase_____ Cycle_____ Volts_____

F.L. Amps _____ Frame_____ S.F._____ Special Info._____

Last Lubrication–Date _____

Grease Used–Type _____

Any Unusual Noise? No ❑ Yes ❑ Action Required _____

Any Unusual Vibration? No ❑ Yes ❑ Action Required _____

Any Unusual Heat Build-up? No ❑ Yes ❑ Action Required _____

inspection and maintenance schedule

General Recommendations

—more frequent inspection and maintenance may be desirable

	Fan and Fan Guard	Motor	Driveshafts and Guards	Geareducer	Eliminators	Fill	Cold Water Basin	Hot Water Distribution System	Float Valve	Suction Screen	Control Valves	Structural Members	Casing	Fan Cylinder	Stairs, Ladders, Walkways, Doors, Guardrails	Davits, Derricks, Hoists	ClearSky PVC Heat Exchangers	ClearSky Dry Dampers and Vent Doors
1. Inspect for clogging					M	M		W		W							M	
2. Check for unusual noise or vibration	D	D	D	D														
3. Inspect keys, keyways and set screws	S	S	S	S														
4. Make sure vents are open				S														
5. Lubricate (grease)		R									S							R
6. Check oil seals				M														
7. Check operating oil level				D														
8. Check static oil level				M														
9. Check oil for water and sludge				M														
10. Change oil				S														
11. Check fan blade tip clearance	S																	
12. Check water level							D	D										
13. Check for leakage				W		S	S	S									S	
14. Inspect general condition	S	S	S	S	Y	S	Y	S	Y	S	S	S	Y	S	S	S	S	S
15. Tighten loose bolts	S	S	S	S														
16. Clean	R	R	R	R	R	R	S	R	R	R	R						R	
17. Repaint	R	R	R	R														
18. Rebalance	R		R															
19. Inspect/repair for safe use	Y		Y												Y			
20. Inspect and repair before each use																R		

D–Daily W–Weekly M–Monthly Q–Quarterly S–Semiannually Y–Yearly R–as Required

F400 Clearsky cooling tower

USER MANUAL

SPX COOLING TECHNOLOGIES, INC.
7401 WEST 129 STREET
OVERLAND PARK, KS 66213 USA
913 664 7400 | spxcooling@spx.com
spxcooling.com

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