

**DESIGN, OPERATION AND MAINTENANCE
MANUAL**

**TTMT FORCED-DRAFT FIBERGLASS
MODULAR COOLING TOWER**

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NOTE TO OUR CUSTOMERS:

Every effort has been made to ensure that the information in this manual is complete, accurate, and up to date. However, Tower Tech Inc., assumes no responsibility for the result of errors beyond its control.

Adequate knowledge of the maintenance and operation of the Tower Tech TTMT series cooling tower will ensure efficient and safe operation. The users should familiarize themselves with the construction, operation, and maintenance of the cooling tower module(s). Failure to do so may cause poor performance, unnecessary equipment failure, and down time. Any questions regarding equipment should be directed to the Tower Tech Service Department at (405) 222-2876.

NOTICE!

**READ ALL PARTS OF
THIS MANUAL BEFORE
INSTALLING OR
OPERATING THE
TOWER.**

**ANY QUESTIONS SHOULD BE
DIRECTED TO TOWER TECH, INC.
SERVICE DEPARTMENT AT
(405) 222-2876**

WARNING!

All electrical, mechanical, and rotating machinery constitute a potential hazard, particularly for those not familiar with the design, construction, and operation of same. Accordingly, adequate measures (including the use of a protective enclosure when deemed necessary) should be taken with this equipment, both to safeguard the public from injury and to prevent damage to the equipment and its associated system.

The operation, maintenance, and repair of this equipment should only be undertaken by qualified personnel. All such personnel should be thoroughly familiar with the equipment, the associated system and controls, and all procedures dealing with the handling, lifting, installation, operation, maintenance, and repair of this equipment to prevent personal injury and/or property damage.

ELECTRICAL HAZARDS WARNING

ALL ELECTRICAL POWER SHOULD BE DISCONNECTED AND LOCKED OUT BEFORE ANY SERVICING OF THE TOWER IS ATTEMPTED. QUESTIONS SHOULD BE DIRECTED TO THE TOWER TECH SERVICE DEPARTMENT AT (405) 222-2876.

For the protection of authorized service personnel, the unit should be installed with a lockable disconnect switch located in close proximity and within sight of the cooling tower unit. No service work should be performed on or near the fan motors without first ensuring that the fan motor has been electrically disconnected and locked out.

CAUTION

The cooling tower must be located at such distance and direction as to avoid the possibility of contaminated tower-discharge air from being drawn into any building fresh-air intake ducts. The purchaser should obtain the services of a Licensed Professional Engineer or Registered Architect to certify that the location of the tower is in compliance with applicable air pollution, fire, and clean-air codes.

Additionally, users of this product must consider the following:

1. The use of untreated water in any cooling tower may cause serious health hazards, including the creation of conditions conducive to the development of legionella bacteria, which is known to cause legionnaire's disease. A water treatment program to stop biological contamination must be used for all cooling tower installations in order to reduce such hazards. **Do not operate this equipment without a proper water treatment program.**

The following are current methods of water treatment. Contact Tower Tech service department for the best method for your application.

Chemical Method

Ozone Method

Electromagnetic Method

2. Concentrations of dissolved solids must be controlled by bleeding a small portion of the circulation water from the system.
3. The cooling tower water must remain in a range of 7 pH in order to have the optimum acidity and alkalinity of the circulating water.
4. Refer to Tower Tech's Operating and Maintenance Manual before start-up of equipment.

CAUTION

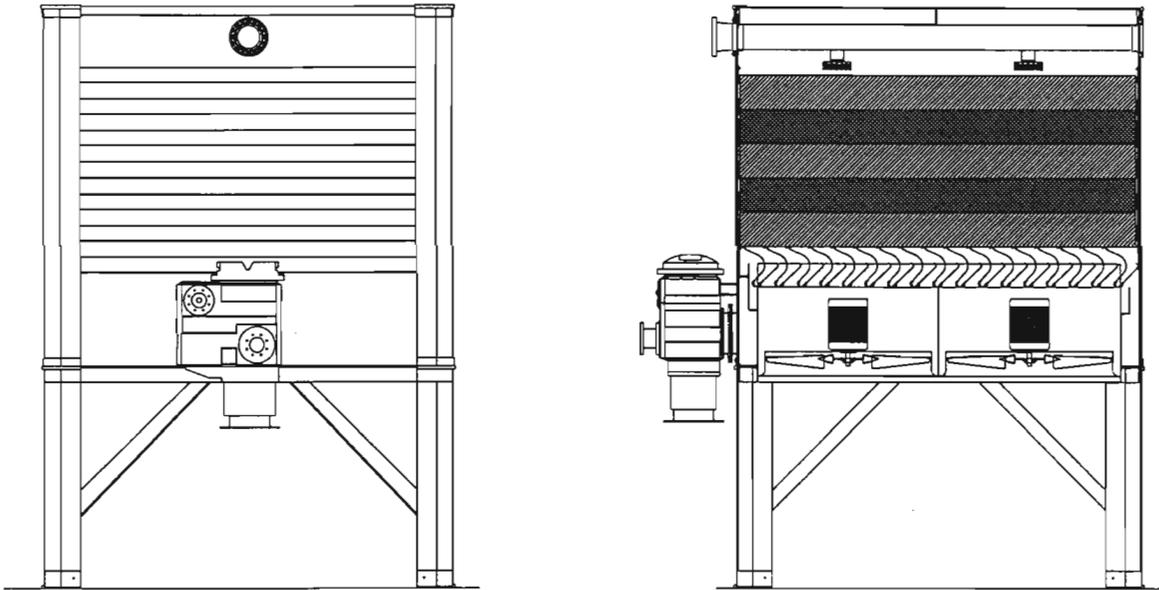
IMPORTANT WATER TREATMENT OPERATING INFORMATION

In order to better assure maximum equipment life span, as well as, health and safety it is recommended that a chemical water treatment program be instituted at equipment start-up. Proper start-up of a new cooling tower system is also critical to preventing initial corrosion and fouling of downstream processing equipment. The following measures should be taken.

1. Cooling tower should be flushed several times, independent of downstream process piping, to remove any dirt, debris, lubricants and milling residues - BEFORE connecting to system piping. In order to protect pumps and other valuable system equipment it is critical that ***in-line strainers be used*** during first few weeks of operation and that they be checked regularly to remove accumulated debris that can adversely impact system pressure. Immediately after completion of flushing, drain tower - DO NOT allow stagnant untreated water to remain in tower system, particularly in basin for long periods of time. This will reduce risk of bio-film formation and ensuing scaling.
2. Once system hydro-testing begins (applicable to new exchangers, condensers etc.) it should be conducted with properly treated water and NOT untreated or poorly treated water. Allowing untreated water to lie stagnant within the cooling system is highly corrosive. Proper start-up entails appropriate pre-treatment washing and passivation steps followed by the on-going use of a well designed water treatment regimen including scale inhibitors, corrosion inhibitors and dispersants. Consult your Tower Tech representative for details on Tower Tech's WATERwatch™ water quality program including a complete line of treatment chemicals, metering and control systems.
3. Cooling towers, as well as, other water atomizing devices (such as sprinklers, misters, shower nozzles) are potential vectors for the spread of *Listeria* the causative agent of Listeriosis (a type of pneumoniae). It is crucial that the tower be routinely treated with appropriate biocidal control agents specifically designed to control the proliferation of *Listeria*. Experts agree that oxidizing biocides (chlorine, hypochlorites, hydantoin, chlorine dioxide, sodium bromide with chlorine, and ozone) are the most effective control agents and should be used at a level sufficient to maintain a 0.5 ppm minimum residual chlorine level. In addition it is recommended that a non-oxidizing biocide (e.g. DBNPA, glutaraldehyde, isothiazoline) be introduced in slug fashion on an intermittent basis to further enhance control. Use of dual biocides lessens the opportunity for biocide resistant strains to gain a competitive advantage. Under no circumstance should a tower be operated without biocide regimen in place.
4. Tower should be located well away from and downwind of building air intakes to further reduce the potential for aerosol to enter buildings. Under no circumstance should a tower be operated without drift eliminators in place and intact.
5. Consult *Water Treatment* Section for further information on daily systems operation.

SECTION I

INTRODUCTION TO THE PATENTED TTMT FIBERGLASS COOLING TOWER



1. TOWER TECH, INC. HISTORY

Tower Tech was incorporated in Sept. 1985, one of a number of small, independently-owned manufacturers of field-erected cooling towers. In the late eighties, a rental division was added to the company to more successfully compete in a market that was being choked by a lingering recession. After a year of design and development, the first truly mobile cooling tower was finished at the Chickasha, Oklahoma plant in 1989. The design, protected by two patents,¹ met with resounding success and the fleet of mobile towers grew to a total of twelve towers in 1992, totaling 180,000 tons of mobile cooling capacity.

While highly successful, the rental fleet's primary use was for emergency tower replacement or for additional cooling needs at peak demand during summer months. In early 1991, a decision to develop a packaged-tower line was made to offset this seasonal variation in income. Since there were dozens of cooling tower companies on the market, all of similar design, it was necessary to develop a tower that could be differentiated from the other manufacturer's towers. Unfortunately, different alone was not sufficient impetus for a customer to justify the purchase of a manufacturer's new tower line. It was imperative that the design significantly improve on the 100-year old design philosophy that permeated the industry.

¹ Patent #'s 4,267,130 and 4,301,097

Paralleling the development of the mobile tower, the new tower had to be packaged so that it could be delivered unescorted on a conventional semi trailer. In addition, it was decided to develop a design that did not need field personnel to assemble. These constraints forced the development of a new water distribution system to minimize the height of the tower. To this height constraint was added a requirement to minimize the ability of the water distribution nozzle to clog. This was essential since a primary deficiency of conventional nozzles is their tendency to clog, especially in dirty-water applications and in applications where bacteriological growth is likely to form. Since cooling tower nozzles are designed for a primary flow rate, and performance drops off dramatically at off-design points, it became obvious that a design that would maintain even water distribution at a wide variety of flow rates would have exceptional market potential. The design that resulted, the Rotary Spray Nozzle, achieved a low water profile by employing a lateral spray pattern, provided essentially clog-free operation by incorporating a turbine into the nozzle, and maintained a spray pattern size and near constant pressure drop by use of a flow-sensitive orifice. The nozzle required less pressure head to atomize the flow since the turbine in the nozzle was a much more efficient device than the atomization approach used in a conventional nozzle. Two patents that covered the design were submitted in 1991 and were awarded in late 1992².

Another design flaw associated with conventional cooling towers deals with the cold-water collection basin beneath the tower. These basins tend to accumulate trash, are exposed to direct sunlight, and generally contain large regions of stagnant water. In combination, these can lead to excessive sediment build-up and increase the need for algaecides and biocides.

A water free-fall zone above the basin that allows airflow into the tower is an integral part of all conventional tower designs. This is a very inefficient portion of the cooling tower from a thermal perspective since the cooling in ten feet of free-fall water could be achieved in less than one foot of fill. The pump energy that is required to lift the tower water above this free-fall zone is an extremely inefficient use of energy.

Tower Tech's enclosed, elevated-basin design eliminated most of the problems associated with conventional basins and removed the inefficient free-fall zone. Pump energy requirements were reduced, basin maintenance was virtually eliminated, and there was a reduction in algaecide use since the basin water was not exposed to sunlight. In addition, the enclosed basin significantly reduced the amount of dirt and trash that is typically blown into an open basin. The self-cleaning nature of the Tower Tech basin eliminated the build-up of sludge, common in stagnant regions of most towers. Bacteria, such as Legionella, can remain protected from chemical attack under this sludge.

The enclosed basin on the Tower Tech design was made possible by the invention of a system of water collection channels above the fans. These channels move the water laterally from the bottom of the fill to the enclosed basin while still allowing air into the fill. Patents for the water collection system were filed in 1994 and awarded in January, 1996.³

The installation of the collectors created a dry region under the tower. This allowed for the removal of the fan from the moist air stream on the top of the tower. Placement of the tower

² Patent #'s 5,143,657 and 5,152,458

³ Patent # 5,487,531

mechanical at ground level greatly increased the longevity and maintainability of the equipment.

To add flexibility to the design, a number of small fans were used instead of a few large fans. This made motor replacement inexpensive and the increased number of fans typically doubled the number of fan set points, allowing the fan power to more closely match the changing load to the tower.

The original design was manufactured of hand-laid fiberglass components. Fiberglass was employed to eliminate the possibility of corrosion that is typically encountered on galvanized towers. The first hand-laid fiberglass tower was sold in June of 1992. From mid 1992 to early 1994, over 130 hand-laid fiberglass towers were produced and sold. Most of the development work and tool costs associated with the tower were financed by the sale of the mobile tower fleet in 1992.

While successful, the hand-laid tower proved too costly to manufacture. Extensive manpower was required to construct the tower and the reliance on man-made parts also made it difficult to maintain consistent tolerances. Also, the added cost of fiberglass priced the tower on the high-side of the market. To counter this, the decision was made to change from a hand-laid fiberglass tower to a pultruded fiberglass design.

An initial stock offering was made in November, 1993 to finance the redesign of the modular tower. Four pultrusion molds, 17 injection molds, one rotational mold, and four fiberglass fan stack molds were designed and built. The plastic parts were made of corrosion-resistant ABS, glass-reinforced nylon, and polyethylene. The pultruded fiberglass parts were some of the largest pultruded parts in the world and Tower Tech was awarded the Composite Structures Association Excellence in Innovation award in 1995. A patent for the pultruded, elevated basin was filed for in late 1993 and awarded in January, 1996.⁴ The first pultruded fiberglass tower was sold in June of 1994.

The success of the pultruded tower can in-part be attributed to a decision to become CTI certified. The pultruded tower design was initially certified by the Cooling Tower Institute in 1993. An annual retest of the tower maintains the certification. To date there are eight manufacturers with certified towers, six domestic and two foreign.

The majority of the package towers sold in the industry are earmarked toward the commercial side of the business. Unfortunately, the size of the pultruded tower does not lend itself to large industrial applications. Tower Tech initiated the development of a tilt-up concrete version of the modular tower in 1994 in order to penetrate this market.

The concrete tower design was modeled after the pultruded fiberglass tower. Concrete walls are poured in place and tilted into position to define the perimeter of each cell. Troughs are added to each wall to channel the collector water out of the cells to a ground-level basin at the end of a row of cells. The collectors rest on the troughs but are also supported from above from the header system due to their expanse. The header and lateral water distribution system are concrete-encased pipes to provide fire protection and to support the collector, fill, and drift

⁴ Patent # 5,487,849

eliminator weight. The tower mechanical is mounted on pillars on the tower slab, providing the same ease of maintenance that is available on the fiberglass design.

Method patents on the concrete tower design were filed in late 1994 and were awarded in August, 1996.⁵ Tower Tech received the Tilt-Up Concrete Association's Achievement Award in 1995 for the tower design. The first tower was sold in April, 1995.

The availability of the pultruded fiberglass tower allowed Tower Tech to reenter the rental market in early 1993. In the event of an emergency, or if additional cooling capacity is required during the peak heat loads of the summer, mobile rental units can be put into service within hours.

An accessory parts division was opened in 1996 to provide customers with detailed information and accessory parts associated with the entire cooling tower system. The unique nature of the Tower Tech tower allows for the design of numerous operating scenarios so that the tower system can be optimized to fit the specific needs of each customer. This often requires that the accessory equipment be designed as part of the total system package. Tower Tech offers for sale pumps, variable frequency drives, centrifugal separators, chlorinators, water treatment equipment, and electrical control panels.

In the course of a decade, Tower Tech has grown from a small wood cooling tower company to the fourth largest domestic supplier of commercial cooling towers. This phenomenal growth was only possible due to the rapid acceptance by industry of the revolutionary concepts employed in the design of the Tower Tech tower. These advances have been detected by many foreign manufacturers of cooling towers and has led to the development of numerous manufacturing rep agreements and the development of joint ventures with companies in Singapore, Italy, India, South Africa, and Brazil.

⁵ Patent # 5,545,356

2. TTMT MODULAR DESIGN

Cooling towers come in a variety of configurations. These configurations can vary according to the type of airflow encountered, the type of draft used, the tower erection site, and the materials of construction. These areas, combined with a myriad of other tower characteristics, are what distinguish one tower from another.

The Tower Tech Modular Fiberglass cooling tower is characterized as a forced-draft, counter-flow cooling tower. A counter-flow tower, as opposed to a cross-flow tower, is distinguished by the fact that the air and water inside the tower flow in opposite directions to one another. In a cross-flow tower the air and water flow perpendicular to one another. Figure I-2.1 shows the layout of a Tower Tech counter-flow cooling tower; Figure I-2.2 depicts a typical cross-flow tower.

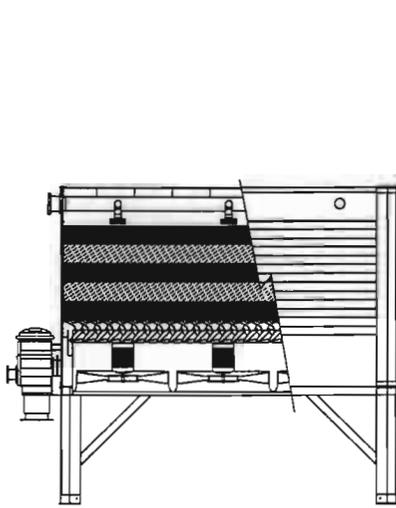


FIGURE I-2.1: TTMT Tower

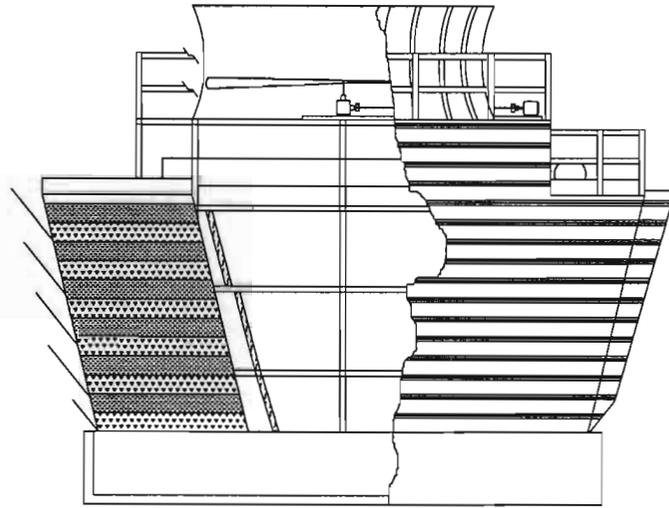


FIGURE I-2.2: Cross-Flow Tower

The Tower Tech tower is also characterized as a mechanical forced-draft cooling tower. Mechanical fans are used to provide a known volume of air through the tower. Forced draft towers have the fan located in the cool, dry, ambient air stream on the entrance side of the tower, pushing air through the tower. Induced draft towers have the fan located in the hot, moist air stream on the exit side of the tower, drawing air through the tower. Neither the fans nor the motors on a forced-draft cooling tower are subjected to the harsh environment encountered in an induced draft cooling tower. The Tower Tech mechanical forced-draft cooling tower design is shown in Figure I-2.3; an induced-draft tower is shown in Figure I-2.4.

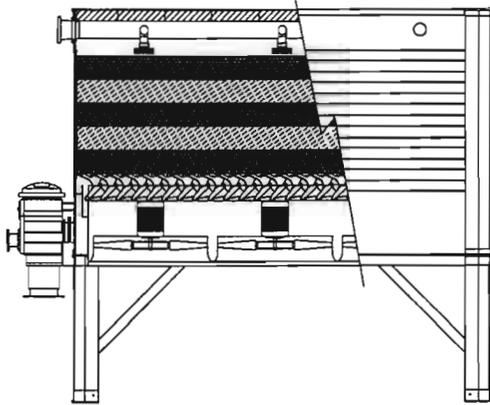


FIGURE I-2.3: TTMT Tower

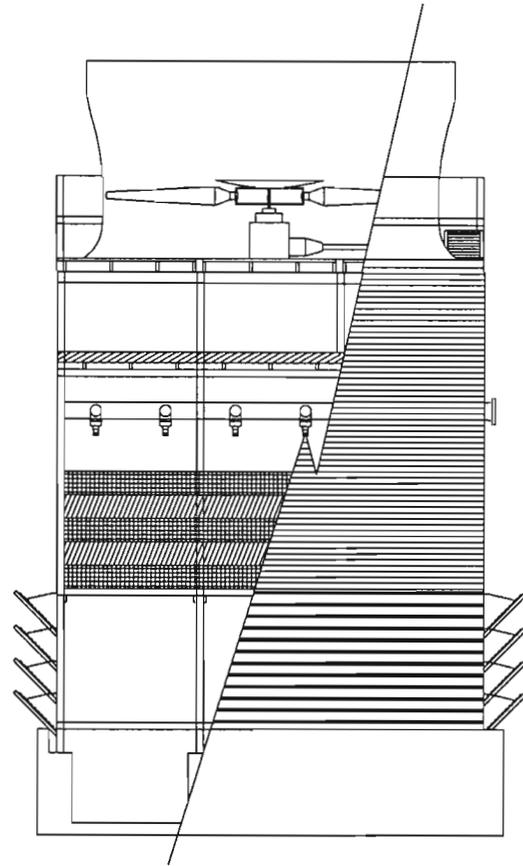


FIGURE I-2.4: Induced-Draft Tower

The Tower Tech fiberglass cooling tower is also distinguished by its modular design, as shown in Figure I-2.5 below. This enables the individual modules to be interconnected in numerous configurations to create virtually any size cooling tower. This design is also quickly adaptable to accommodate future expansion of cooling tower capacity.

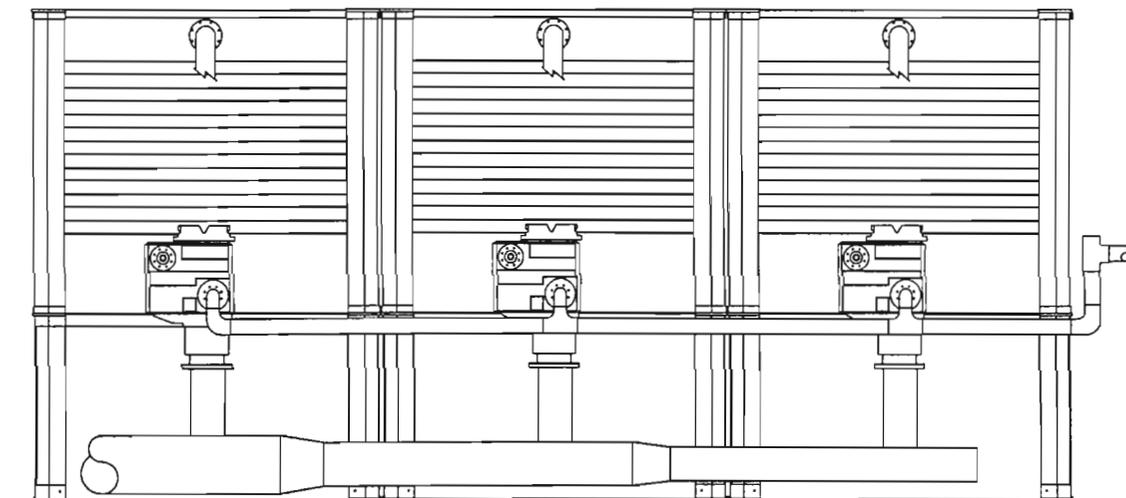
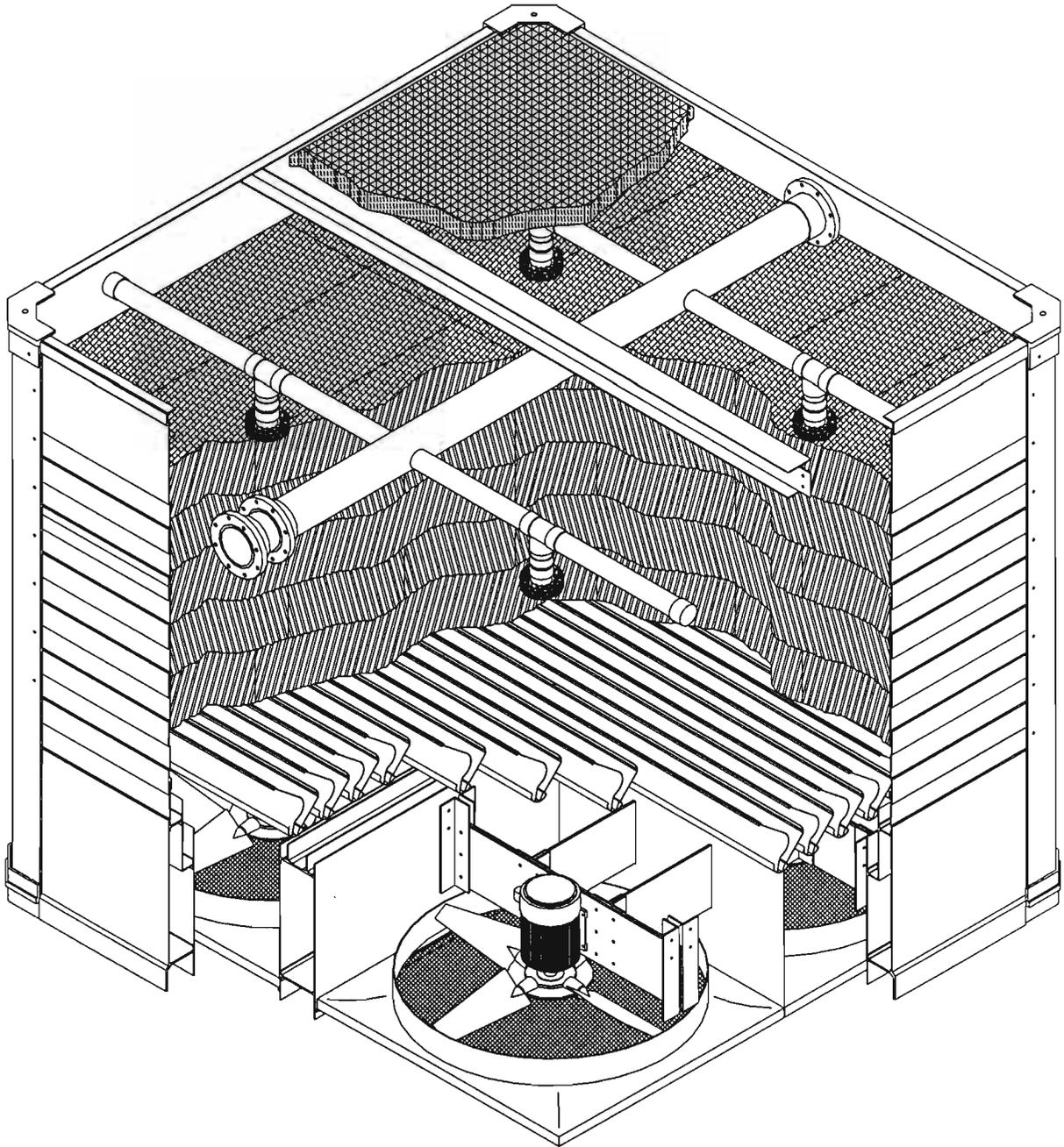


FIGURE I-2.5: Typical Modular Tower Layout

SECTION II

TOWER TECH MODULAR TOWER DESIGN



1. TOWER STRUCTURE

A. Materials of Construction

The Tower Tech Modular Fiberglass Cooling Tower is factory-assembled, as opposed to being field-erected, and is constructed entirely of pultruded fiberglass, plastics, and stainless steel hardware. The pultruded fiberglass pieces, which make up the structure of the tower, were engineered to interconnect and mate properly, providing a rigid structural base for the tower that will resist deterioration and corrosion indefinitely. Plastics are used throughout the internals of the tower to provide long-life, ease of assembly, and cost-effectiveness. Stainless steel hardware is used exclusively on the towers to resist the corrosive environment inherent in cooling towers. This harsh environment has led many manufacturers to the use of galvanized steel and treated wood in their towers. Neither of these products, however, can offer the longevity and environmental safety that can be offered by the fiberglass construction of the Tower Tech Modular Cooling Tower.

A quick overview of the materials used in the construction of a Tower Tech Modular Fiberglass Cooling Tower is shown in Table II-1.1 below. Also shown in the table are the specific processes used to manufacture each component of the tower.

TABLE II-1.1: Materials of Construction

COMPONENT	MATERIAL	PROCESS
Legs, Walls, Assembly Angles	FRP ¹	Pultrusion
D.E. Supports, Header Supports	FRP ¹	Pultrusion
Fan Shrouds	FRP ¹	Chopped Fiberglass
Assembly Fittings	18% Glass-Reinforced Nylon	Injection Molding
Lifting Cap, Base Support, Footpad	18% Glass-Reinforced Nylon	Injection Molding
Header Flange, Sump Flange	18% Glass-Reinforced Nylon	Injection Molding
Clean Out Flange*	18% Glass-Reinforced Nylon	Injection Molding
Fan Blades	30% Glass-Reinforced Nylon	Injection Molding
Fill, Drift Eliminators	PVC ³	Calendering
Piping	PVC ³	Extrusion
Nozzle Head, Rotor, & Deflector	Polyethylene	Injection Molding
Sump	Polyethylene	Rotational Molding
Collectors	ABS ²	Extrusion
Collector End Caps and Spacers	ABS ²	Injection Molding
Nozzle Baffle	ABS ²	Injection Molding
Make-Up Flange, Heater Probe Flange*	ABS ²	Injection Molding
Lifting Plate	Stainless Steel	N/A
Hardware	Stainless Steel	N/A
Sealant	Polyurethane	N/A

* Optional Equipment

¹ Fiber Reinforced Plastic

² Acrylonitrile Butadiene Styrene

³ Polyvinyl Chloride

Galvanized metal support systems and chemical wood treatments are major contributors to serious environmental problems associated with conventional cooling towers. Galvanized structures can molecularly break down and introduce metals into the water due to the high concentrations of acids and alkaline in the cooling tower water. The wood structures of conventional towers are often treated with potentially hazardous chemicals to prolong their life. These substances also leach into the cooling water. The EPA enforces stringent guidelines on the disposal of waste water, commonly referred to as blowdown, due to the presence of these components in the water.

The TTMT Series fiberglass cooling tower has addressed and corrected these two major environmental problems by eliminating the galvanized metal and treated wood from the fiberglass cooling tower.

B. Tower Framework/Substructure

The tower basin and casing materials are comprised of 1/4" thick pultruded fiberglass. The manufacturing process involves pulling continuous lengths of fiberglass material from a resin bath through a heated steel die. The pre-engineered shapes interconnect to insure the structural integrity of the TTMT Series tower.

The fiberglass basin sections, which serve as a perimeter beam, rest on a modular base support. See Figure II-1.1. These wall sections are then through-bolted with stainless steel hardware to four corner enclosures. A top cap and lifting plate are attached to the top of the corner enclosure to provide a lifting point. The fan-motor gussets are then bolted to the basin structure. Intermediate and top casing panels are then set on the basin beam using a tongue and groove joint. Fiberglass I-beams that span between the top walls serve as structural members as well as support for both the piping system and drift eliminators. The unique layout of the distribution system also provides additional structural strength.

The modular tower can be set on stub-leg kits that then mount to a raised platform provided by the customer or the tower can be set on optional fiberglass legs that are braced to the basin beam.

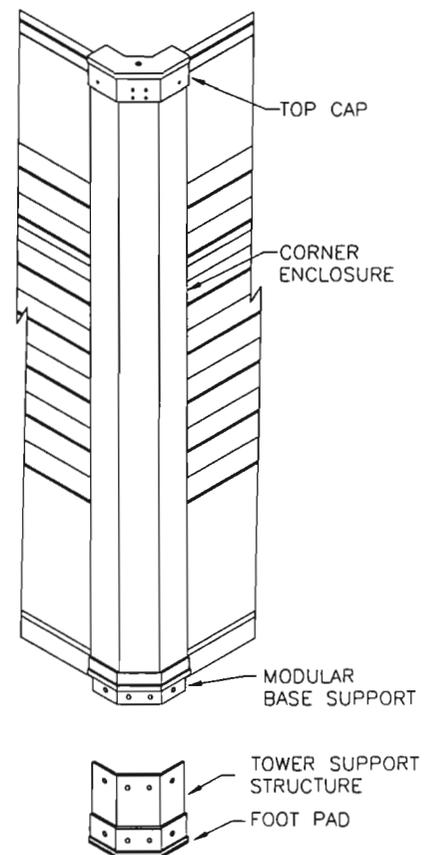


FIGURE II-1.1: Tower Framework

C. Tower Walls

The tower walls provide a perimeter shell around the tower fill. The three sections, basin, mid, and top wall, are some of the largest pultruded fiberglass components in the world. The basin wall is both a structural member and a water storage vessel. A polyurethane sealant is used in the tongue and groove joint where the walls meet to eliminate leaks. A channel is pultruded into the top wall to provide a lip for the drift eliminators. The tower walls are joined to the corner enclosure using stainless steel hardware to prevent corrosion. An illustration of the wall section assembly is shown in Figure II-1.2 below. The three wall sections, in their respective positions, are shown, along with a close-up of the unique tongue and groove joint used at the wall connections.

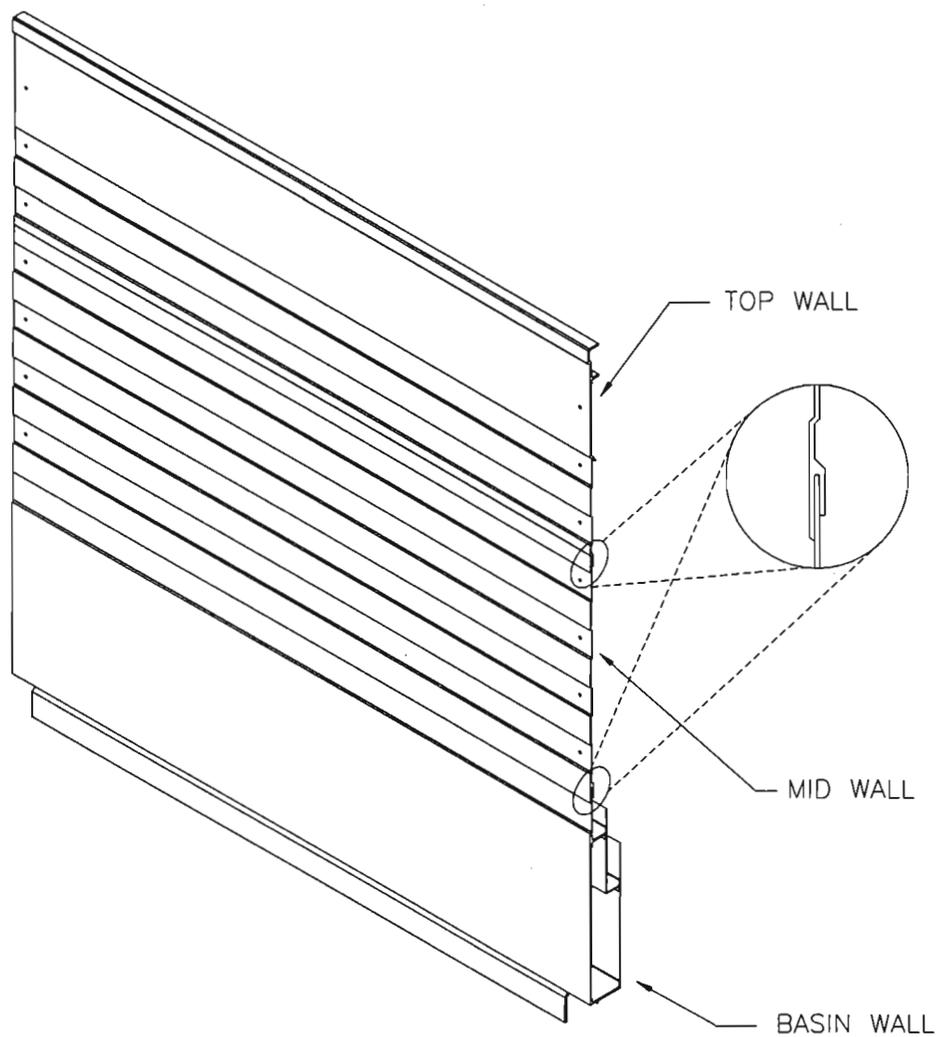


FIGURE II-1.2: Tower Walls

D. Fan-Motor Gussets

Motor gusset plates that are bolted to the basin beams provide structural strength to the tower box and support for the tower motors. These motor gussets are produced from ½" pultruded fiberglass sheets. Although these fiberglass sheet's primary function is to serve as a structural member, they also provide excellent dampening of any fan or motor vibration that may occur. This can eliminate the need for vibration isolators in many installations, thereby reducing total installation costs. The gussets are attached to the perimeter basin beam using pultruded fiberglass angles and stainless steel hardware. The fans and motors are then mounted directly to the gussets with stainless steel hardware. After installation, the fans are adjusted to allow a nominal ¼ inch tip clearance in the fan-stack throat. The layout of the fan-motor gusset support is shown below in Figure II-1.3. The fans and motors are also shown attached to the support structure to provide an understanding of the gusset's function and placement.

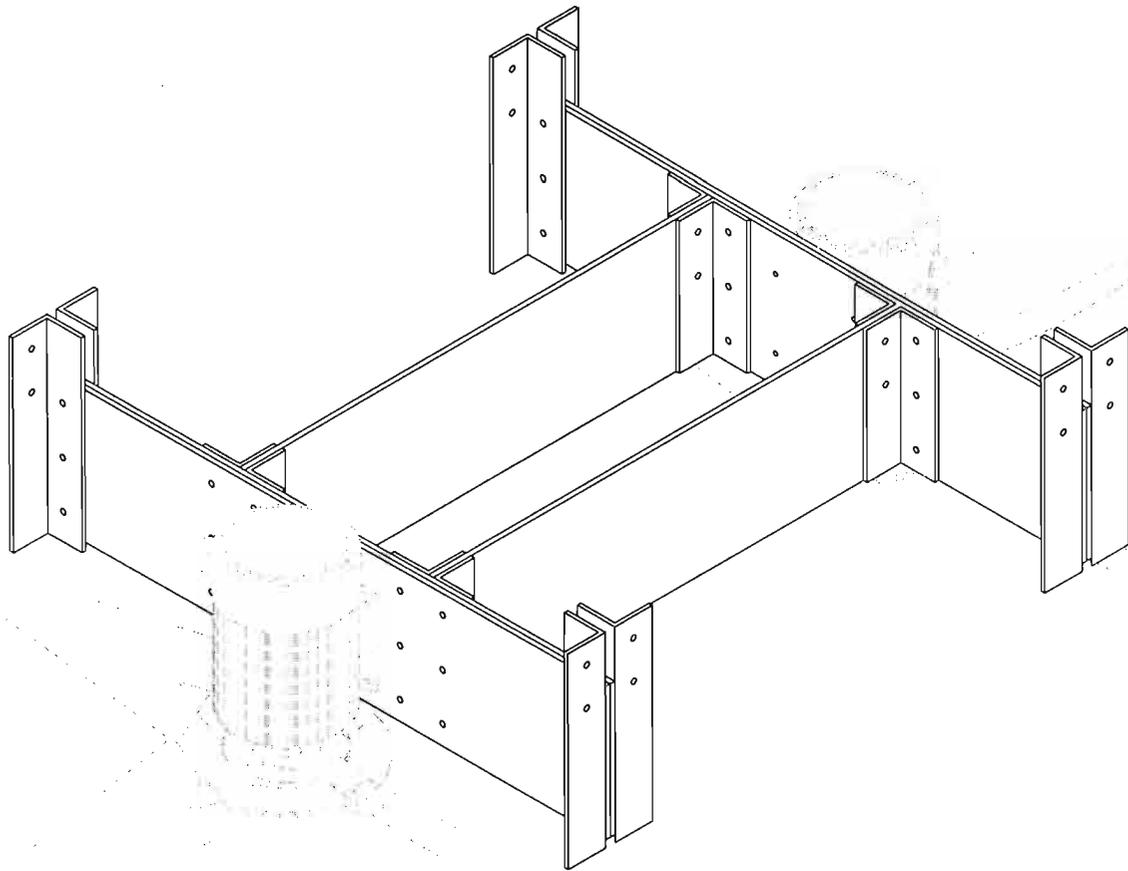


FIGURE II-1.3: Fan-Motor Gusset Support Structure

2. TOWER INTERNALS

A. Drift Eliminators

The TTMT Series Cooling Tower utilizes a low-pressure sinusoidal-shaped drift eliminator that uses three distinct changes in flow direction to enhance the drift capturing ability of the eliminator. See Figure II-2.1. The PVC material used in the construction is virtually impervious to rot, decay, or biological attack. An ultraviolet inhibitor manufactured into the product extends the life expectancy. Properties of the drift eliminators are detailed in Table II-2.1.

TABLE II-2.1: Drift Eliminator Data

Sheet Thickness	15 mil (0.38 mm)
Standard Dry Weight	1.25 lb/ft ² (6.1 kg/m ²)
Standard Materials	PVC or HPVC
Standard Module Depth	5.5 in (140 mm)
Standard Module Width	12 in (300 mm)
Standard Module Length	72 in (1800 mm)
Number of Forced Direction Changes	3
Drift Loss	0.002%
Flame Spread Rating	< 15

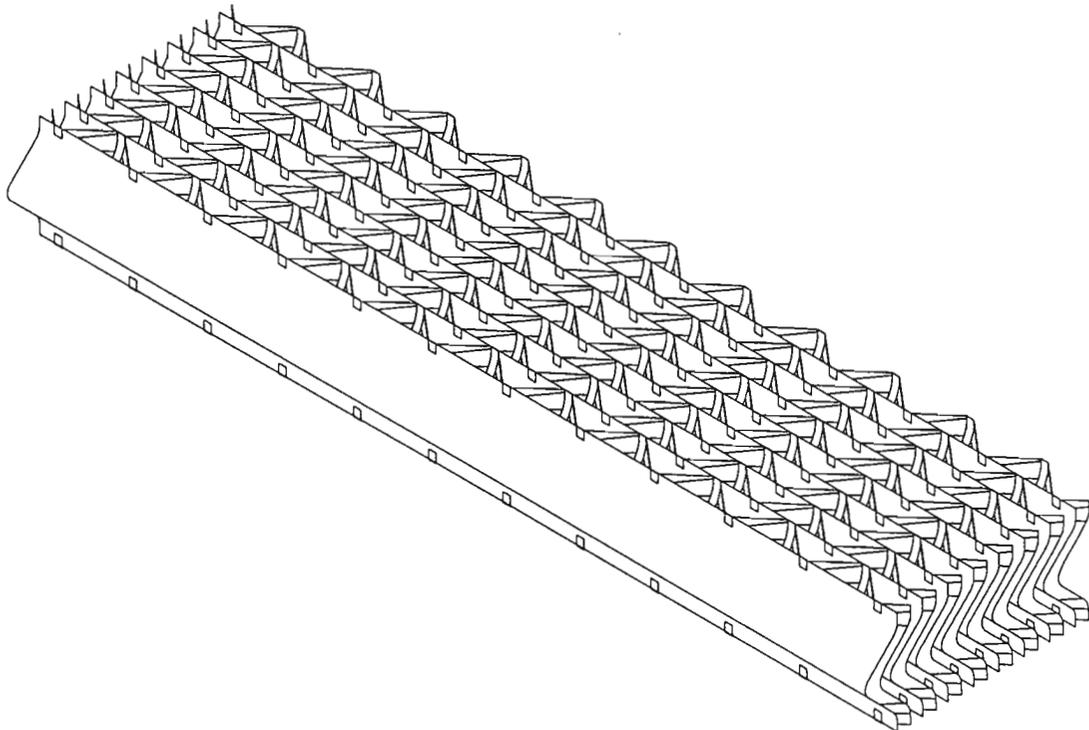


FIGURE II-2.1: Drift Eliminator

B. Water Distribution System

Piping

Hot water enters the TTMT Series Modular Cooling Tower through a PVC header that supplies the distribution laterals. These laterals also serve as a foundation for the mid-span drift eliminator supports. In high temperature installations, both the main header and the laterals can be ordered in CPVC material. The laterals have been pre-engineered to provide each nozzle with the same percentage of the total flow rate. This allows the tower to operate more efficiently by providing an even water distribution to the total fill area. End caps to these laterals join directly to the tower top wall, allowing the piping system to serve as an extra structural member for the top of the tower. This unique piping layout is shown below in Figure II-2.2.

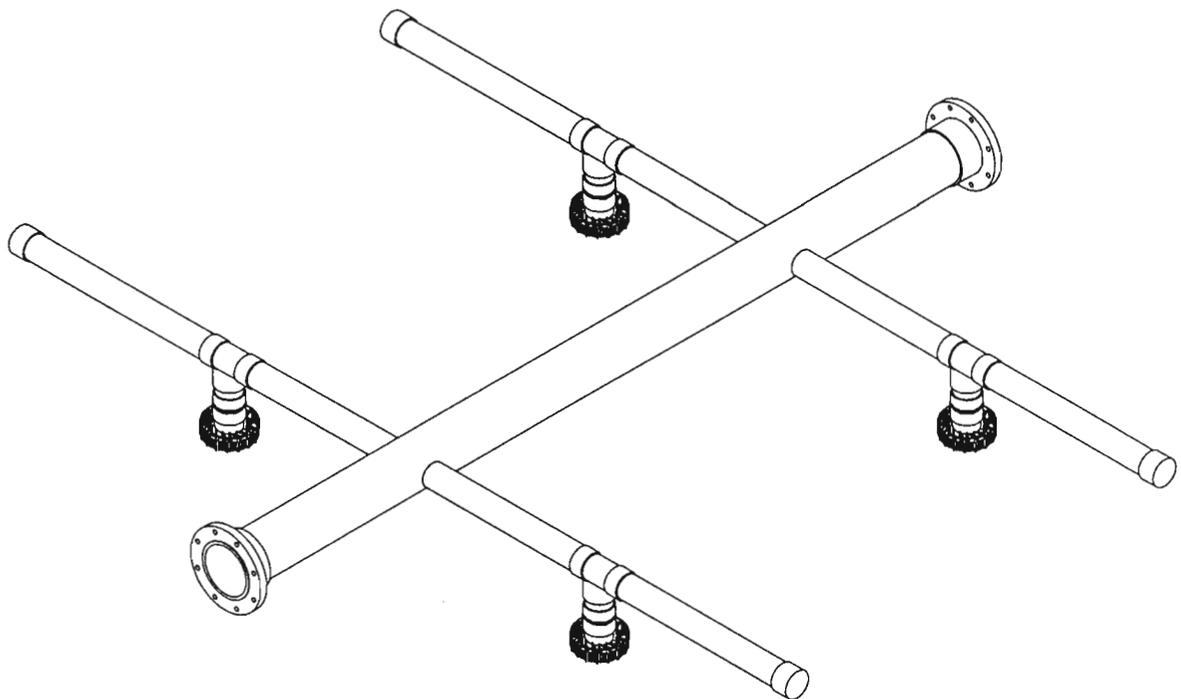


FIGURE II-2.2: Typical Distribution Piping Layout

Patented Rotary Spray Nozzle

Tower Tech's patented¹ Rotary Spray nozzle is used to disperse the water from the laterals to the fill media. The Rotary Spray Nozzle requires less pressure to operate than a conventional nozzle, is virtually maintenance free, and dramatically improves tower performance.

The Rotary Spray Nozzle requires less pressure head to operate than a conventional nozzle by combining a low-profile spray pattern with a low-pressure orifice. Use of a lateral spray pattern allows the nozzle to be positioned just one inch off of the fill material, saving several

¹ Patent #'s 5,143,657 and 5,152,458

feet of pump head. In addition, the use of a turbine in the nozzle to atomize the flow is much more efficient than the atomization approach used in a conventional nozzle.

Tower Tech's Rotary Spray Nozzle is also virtually maintenance free. Debris that typically clogs conventional nozzles will pass directly through the Rotary Spray Nozzle. This is accomplished by the agitation action provided by the nozzle's turbine-driven rotor. The nozzle rotor spins on a water bearing that is formed within the nozzle. This bearing keeps the nozzle parts from wearing, thus providing years of virtually clog-free service. An illustration of the Tower Tech Rotary Spray nozzle is shown in Figure II-2.3 below.

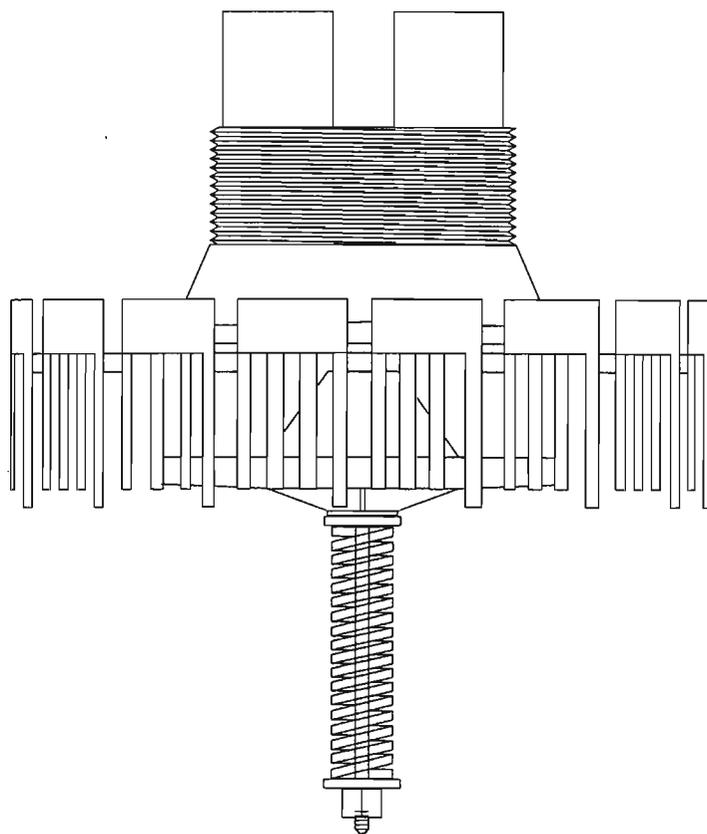
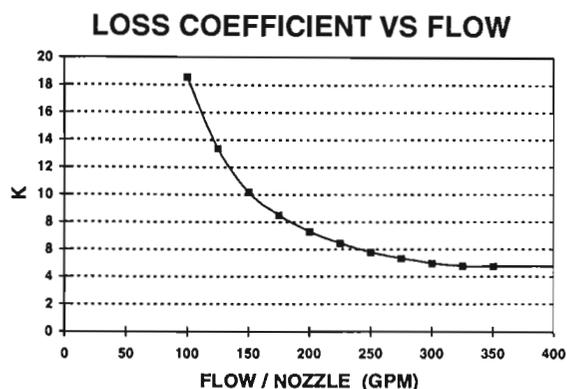
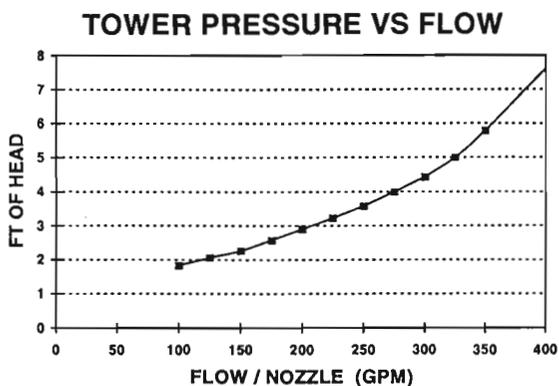


FIGURE II-2.3: Tower Tech Rotary Spray Nozzle

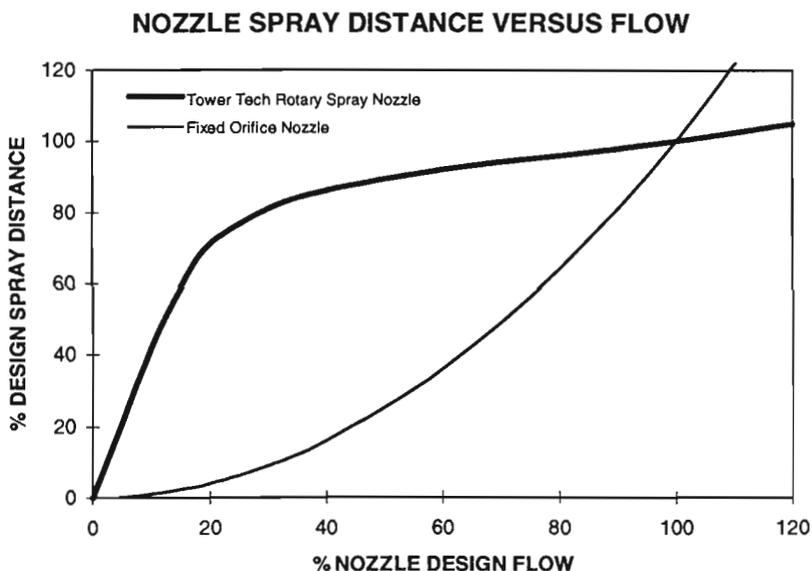
Significant increases in performance can be achieved with the use of the Rotary Spray Nozzle because of improved fill coverage and control of the flow pattern size. The Rotary Spray Nozzle orifice is shaped to provide a square spray pattern, thereby uniformly wetting the entire tower's fill. This improves tower performance and reduces the likelihood of scaling due to the occurrence of dry regions within the fill. The nozzle is also equipped with a spring-loaded orifice to allow the nozzle to automatically adjust to changes in the flow rate. This innovation has allowed for a uniform water loading for a wide variety of flow rates. This significantly reduces the fall-off in performance that is customarily observed in conventional towers when the flow rate is altered.

This uniform spray pattern was accomplished by designing a spring-loaded orifice plate that provides a varying cross-sectional area as flow rate changes. This allows the piping head pressure to remain much more constant than fixed-orifice nozzles, by reducing the loss coefficient encountered in the nozzle at high flow rates. By eliminating the extreme pressure

increases associated with increased flow rates, Tower Tech was able to produce a much more consistent nozzle spray pattern as flow rates varied. Charts showing the variation in the tower piping head pressure and nozzle loss coefficient versus flow rate per nozzle are shown below.



As can be seen from these charts, the operating parameters of the nozzle should remain between 100 GPM and 350 GPM. Above or below these points, some variation in nozzle effectiveness could be seen. Although these charts provide further engineering insight as to how the Tower Tech Rotary Spray nozzle operates, the actual benefits of the nozzle over fixed orifice nozzles can more easily be seen in the chart below.



From this chart, the wide-range capabilities of the Tower Tech Rotary Spray nozzle are evident. With a design flow rate of 300 GPM, the nozzle can perform very well from about 30% of design flow to about 115% of design flow, or from 100 GPM to 350 GPM. This capability is not present in the fixed orifice nozzle, as it must remain very near design flow to be effective. The benefits in design of the Tower Tech Rotary Spray nozzle are most evident in the associated energy and cost savings available when the total flow can be varied to each nozzle. For instance, as load to a tower decreases, most systems will decrease flow rate in the

cooling tower circuit. As this flow rate is decreased, a tower with fixed orifice nozzles must be cycled off to allow the remaining cells to receive the design flow. In a Tower Tech tower, however, the lower flow can be distributed to all cells. This allows the flow to be distributed over the entire fill media surface, providing a more efficient use of the available cooling capacity. Horsepower savings from this increase in efficiency can lead to staggering decreases in energy consumption, as part load conditions are much more prevalent than full load conditions.

C. Fill Media

One of the single most important components of a cooling tower is the heat transfer surface, or fill. The fill efficiency is determined by its ability to promote intimate contact between the air and water with minimal resistance to the air flow. The fill used by Tower Tech meets rigorous standards of the cooling tower industry by having uniform thickness, and being free from holes, air bubbles, foreign matter and other manufacturing defects which may adversely affect the performance.

The TTMT Series cooling tower is equipped with five feet of PVC cellular fill media. This media is designed to deliver maximum performance while minimizing the potential for "plugging." For clean water application, such as HVAC installations, a cross-fluted fill may be used to maximize performance in a restricted space and minimize the number of modules required. For extremely dirty water applications, such as pulp and paper mills, a vertically-fluted fill may be required.

Fill Selection

The selection of the fill media will vary from one installation to another due to variances in water quality. The following are a few of the many options.

Air Conditioning (clean water) applications where space is limited, a fill with small flute may be used. This would minimize the square footage required for the cooling tower and give the maximum efficiency.

Industrial (medium water quality) applications would benefit from the use of standard flute size fill to minimize the potential for plugging while maintaining performance efficiency.

Pulp and Paper Mills (extremely poor water quality) require the use of large vertical fluted fill to minimize the potential for plugging.

Hot Water (any quality water) in excess of 130° is considered too hot for PVC fill. For applications with hot water from 130° to 155°, a high temperature HPVC fill media should be used.

On the following pages are descriptions of the various types of cellular fill offered by Tower Tech. These fill choices are available to fit virtually any cooling capacity or water quality. PVC fill material is standard in the TTMT Series cooling towers, however in high temperature applications the fill may be special ordered in HPVC material. All specifications included with each fill option will remain consistent regardless of the material chosen, providing that the mil thickness and module size remain constant.

CF1900 Series Fill

Tower Tech's series CF1900 fill is a cross-corrugated media with a high surface to volume ratio and is best suited for industrial applications that require maximum cooling efficiency and reduced horsepower requirements. Typical applications include electric generation, petrochemical, air conditioning, refrigeration, and other manufacturing processes.

TABLE II-2.2: CF1900 Series Fill Data

Sheet Thickness	10 or 15 mil (0.25 or 0.38 mm)
Standard Dry Weight	1.8 lb/ft ³ (29 kg/m ³)
Standard Materials	PVC or HPVC
Standard Module Depth	12 in (300 mm)
Standard Module Width	24 in (600 mm)
Standard Module Length	72 in (1800 mm)
Surface Area	48 ft ² /ft ³
Flute Height	0.75 in
Diverging Angle	30°
Flame Spread Rating	<10

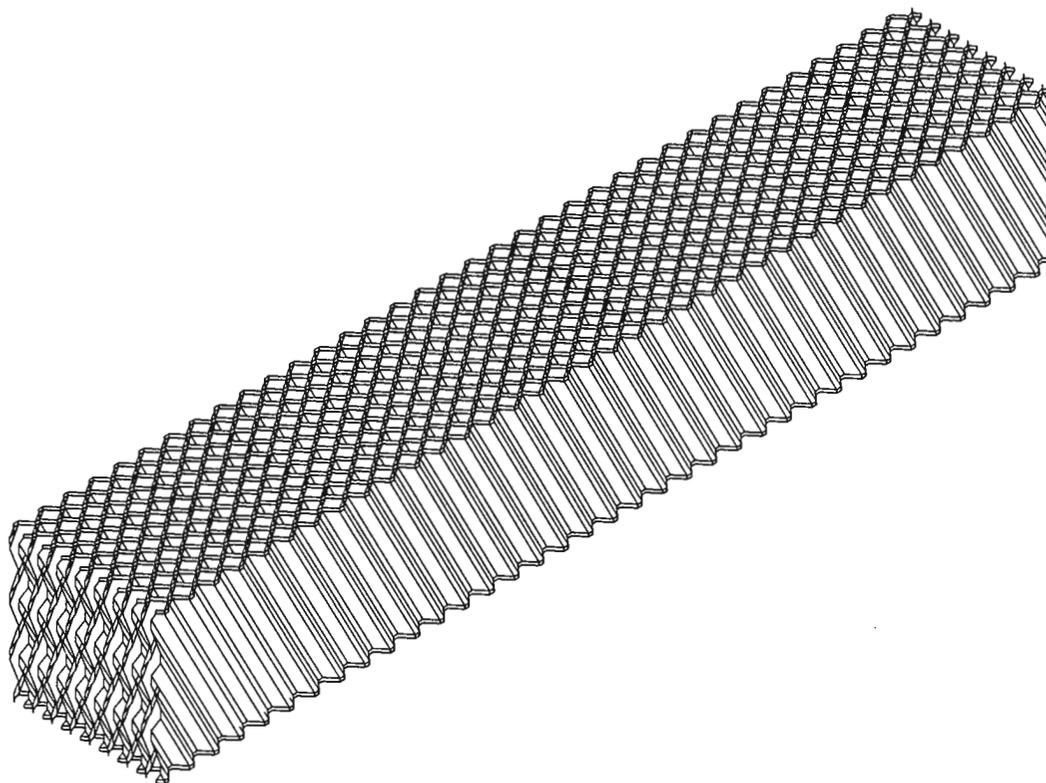


FIGURE II-2.4: CF1900 Fill Media

VF3800 Series Fill

Tower Tech's series VF3800 fill is a vertical-fluted, low-fouling design that provides exceptionally high heat transfer capabilities not possible with other non-fouling fills. Applications include electric generation, petrochemical, steel mills, pulp and paper mills and all other applications where high efficiency must be combined with low fouling.

TABLE II-2.3: VF3800 Series Fill Data

Sheet Thickness	12 or 15 mil (0.25 or 0.38 mm)
Standard Dry Weight	2.3 lb/ft ³ (37 kg/m ³)
Standard Materials	PVC or HPVC
Standard Module Depth	24 in (600 mm)
Standard Module Width	12 in (300 mm)
Standard Module Length	72 in (1800 mm)
Surface Area	40 ft ² /ft ³
Flute Height	1.5 in
Diverging Angle	0°
Flame Spread Rating	<10

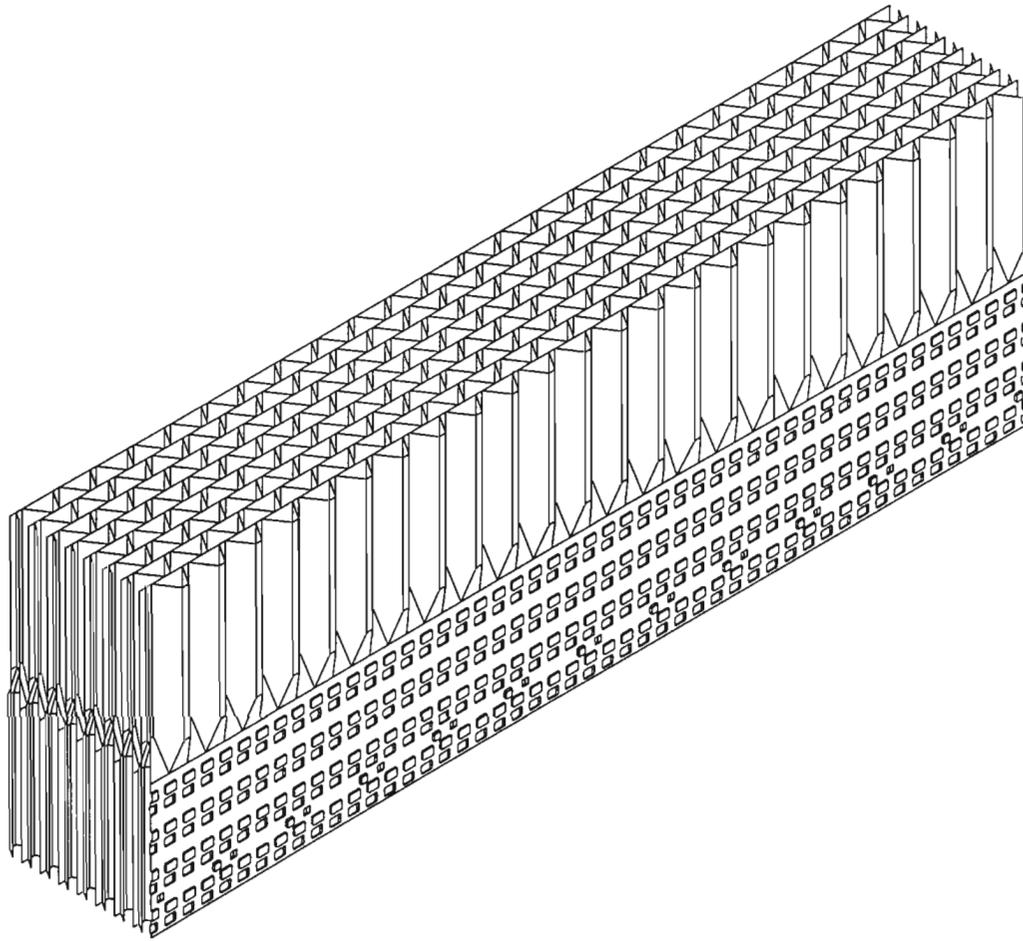


FIGURE II-2.5: VF3800 Fill Media

VF5000 Series Fill

Tower Tech's series VF5000 fill is a large vertical-fluted, non-fouling design that provides fair heat transfer capabilities, while virtually eliminating fouling problems. Applications include electric generation, petrochemical, steel mills, pulp and paper mills and all other applications where fouling is a major concern.

TABLE II-2.4: VF5000 Series Fill Data

Sheet Thickness	15 mil (0.25 or 0.38 mm)
Standard Dry Weight	2.2 lb/ft ³ (35 kg/m ³)
Standard Materials	PVC or HPVC
Standard Module Depth	24 in (600 mm)
Standard Module Width	12 in (300 mm)
Standard Module Length	72 in (1800 mm)
Surface Area	30 ft ² /ft ³
Flute Height	2.0 in
Diverging Angle	30°
Flame Spread Rating	<10

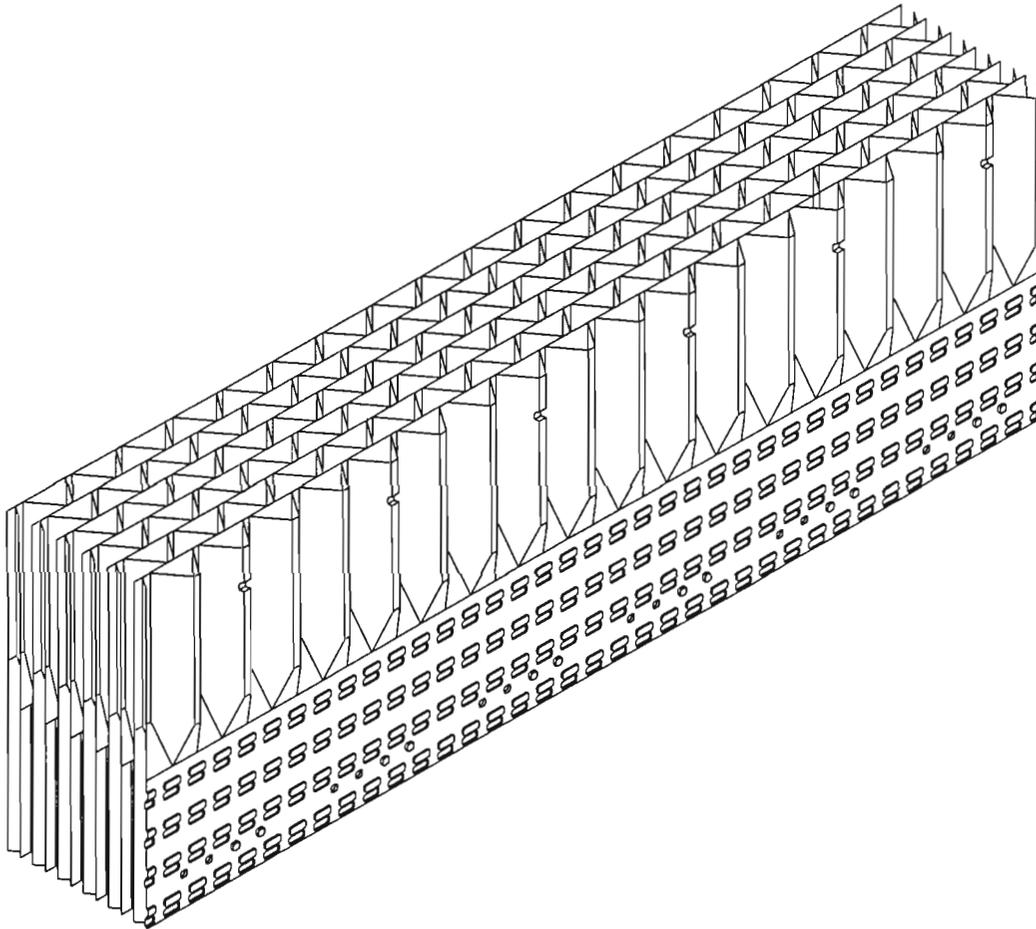


FIGURE II-2.6: VF5000 Fill Media

D. Water Collection System

Collector Design

Tower Tech has patented² a unique water collection system for the Tower Tech Modular Fiberglass Cooling Tower that is positioned above the motor and beneath the fill media. This revolutionary water collection system is comprised of a series of ABS vanes overlapped to provide an interface between the air and water while maintaining a complete wet/dry barrier between the down-coming water and the mechanical equipment. The collectors permit the fans to be placed at ground level, where they can be easily serviced. The collectors also allow for an elevated basin, which significantly reduces pump head.

The profile of two assembled collectors is shown in Figure II-2.6. Each individual collector is comprised of a primary and secondary collector vane, along with an operational baffle supported at both ends by a primary and secondary baffle support lip. A spacer is utilized to maintain the correct distance between each collector.

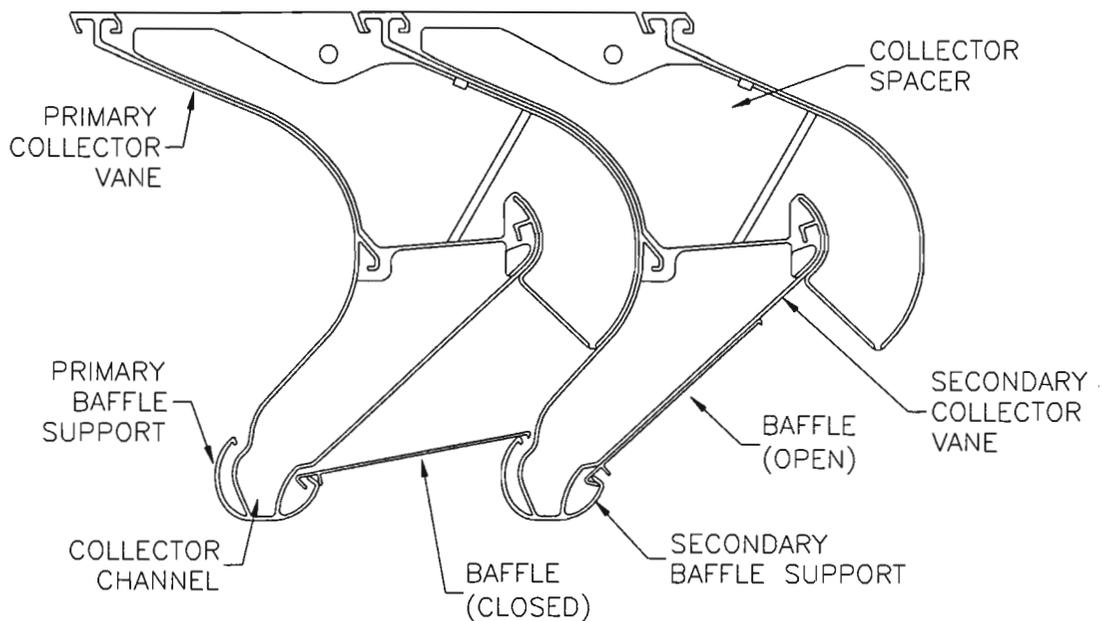


FIGURE II-2.7: Tower Tech Collector Design

The major function of the collector is to separate the falling water from the motors and fans located below. When water exits the fill media it falls onto the leading edge of the collector, known as the primary collector vane. The water then drains into the narrow tubular portion of the collector between the primary and secondary vanes, called the collector channel. The water travels along the collector channel until it empties into the cold water basin walls located on the tower perimeter. From there it is directed into the sump. Air from the fan is simultaneously forced upward through the open spaces between the primary vane of one collector and the secondary vane of the preceding collector. The force applied to the water by the incoming air ensures that the falling water enters the collector channel. When the fan is

² Patent # 5,487,531

not in operation, baffles at the bottom of the collectors close, thereby eliminating any small drops from exiting onto the fan equipment. Small channels on the sides of the main channel direct any small drops to the tower basin. An illustration of this process is shown in Figure II-2.7.

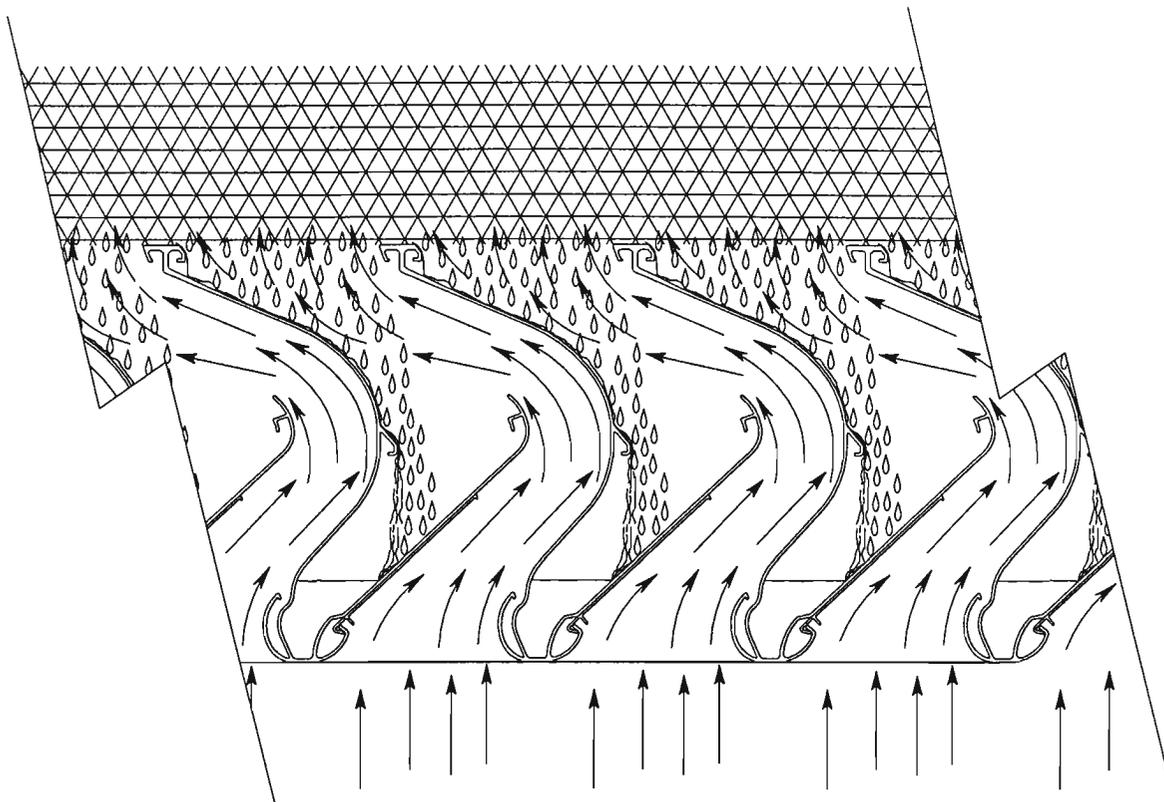


FIGURE II-2.8: Collector Operation

Each collector is extruded at the Tower Tech manufacturing facility from high quality ABS plastic on a state of the art extrusion line to ensure that rigorous quality standards are maintained.

NOTE: The ABS plastic used in the collector assemblies has a deformation temperature of 210° F. Temperatures above this point should be avoided as damage to the collectors will ensue. With proper care and maintenance, the ABS collector assemblies will provide years of reliable service.

Flow-Through Basin

Tower Tech engineers have completely removed the concrete cold-water basin from the module design. To accomplish this, state-of-the-art fiberglass pultrusion technology was utilized to produce special-shaped beams and panels. Four perimeter double-wall beams interconnect with one double-wall center beam to form the basic structure of the module. The enclosed beams double as the cold water basin. In effect, the double-wall beams react to flowing water the same as piping would. High velocities in the basin beams continuously scrub the walls and floor of the basin to eliminate the build-up of sediment. A cross-sectional view of the internal structure of the flow through basin is shown in Figure II-2.8. The fans and motors are also shown in the figure to show the placement of both the perimeter beams and center beam. The collectors are positioned directly above these basin beams, allowing the water to be gravity fed into the double wall sections. The water then flows through these beams, into the sump located on the side of the tower, where the water is extracted from the discharge connection. At no point in the system is the water allowed to stagnate. This prohibits the formation of sediment and biological build-up.

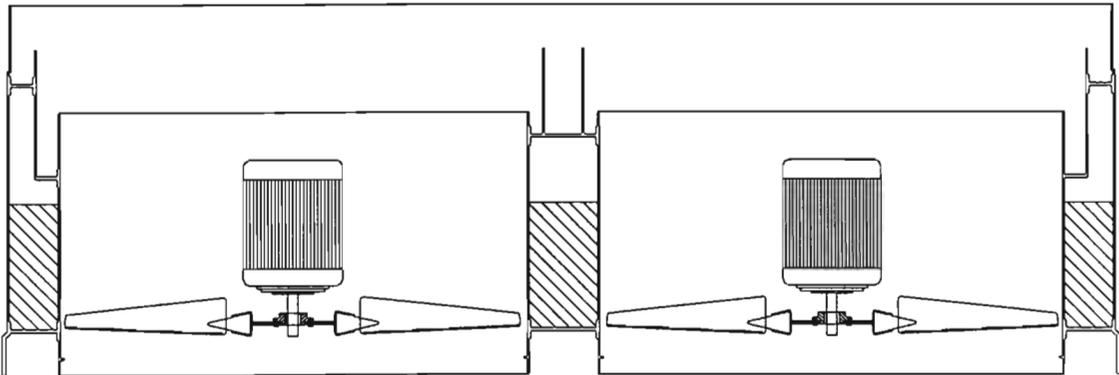


FIGURE II-2.9: Flow-Through Basin

3. SUMP DESIGN

Each Tower Tech module is equipped with a side mounted outlet sump that is flanged for easy installation.³ Standard equipment for each basin includes a threaded make-up water connection, a mechanical float valve that is removable through the sump lid, a flanged overflow/equalization connection, and a sump screen to collect large pieces of debris that may have entered the system. The TTMT Series cooling tower can be equipped with a two-inch threaded connection as well as a ¾-inch connection to receive the optional basin heater package (See optional equipment). An exploded view of the sump, showing all the connections is shown below in Figure II-3.1.

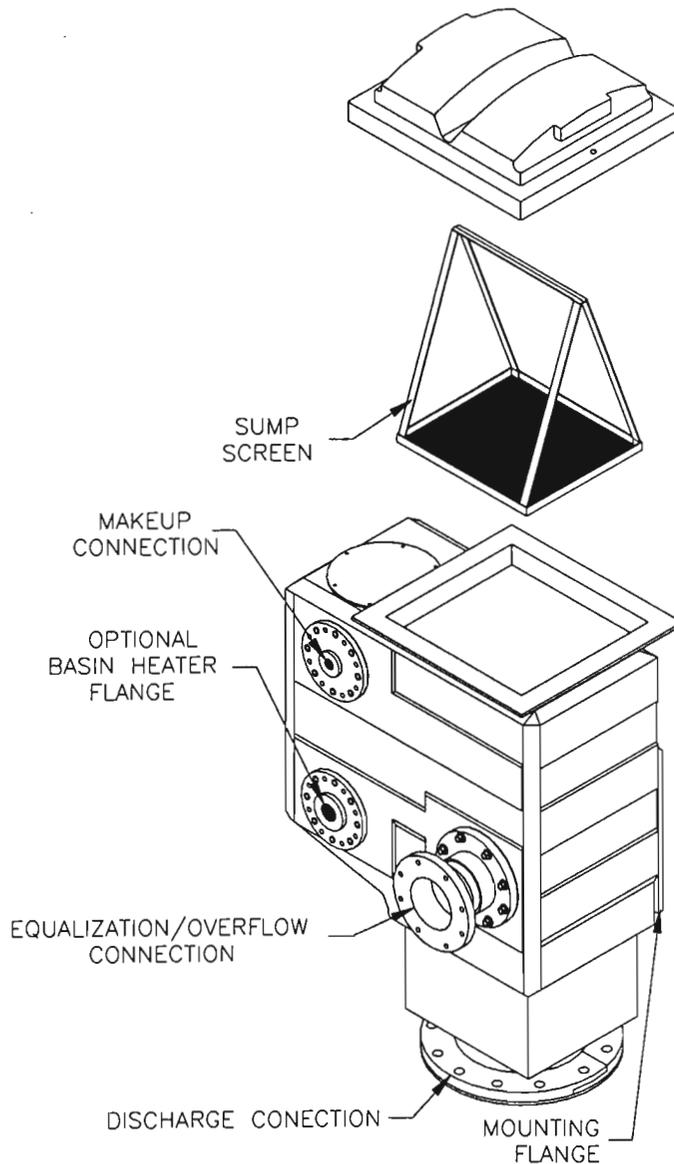


FIGURE II-3.1: Sump Layout

³ All piping should be installed by qualified personnel who are familiar with local, state, and federal regulations.

Sump flange and pipe sizes vary depending upon the selected model. Table II-3.1 lists typical connection sizes for the TTMT Series of cooling towers.

TABLE II-3.1: Sump Pipe Sizes

TTMT SERIES #	STANDARD SUMP CONNECTION SIZES		
	OUTLET	EQUALIZATION / OVERFLOW	MAKE-UP
TTMT-36	8" 150#	4"	1" FNPT
TTMT-72	8" 150#	4"	1" FNPT
TTMT-108	10" 150#	4"	1" FNPT
TTMT-144	10" 150#	6"	1" FNPT
TTMT-216	12" 150#	6"	2" FNPT
TTMT-288	14" 150#	6"	2" FNPT
TTMT-360	14" 150#	6"	2" FNPT

A. Make-Up Connection / Float Valve

The TTMT Series cooling tower is supplied with either a one or two inch brass float valve, shown in Figure II-3.2 below. The connection fitting is located on the front of the sump in the upper left hand corner. The fitting is Female Nautical Pipe Thread (FNPT). This valve is built to withstand the turbulence encountered in high-flow cooling tower applications. All valve components are made of either brass or stainless steel, providing corrosion resistance in this harsh environment. The connection flange is made from high quality ABS to eliminate corrosion.

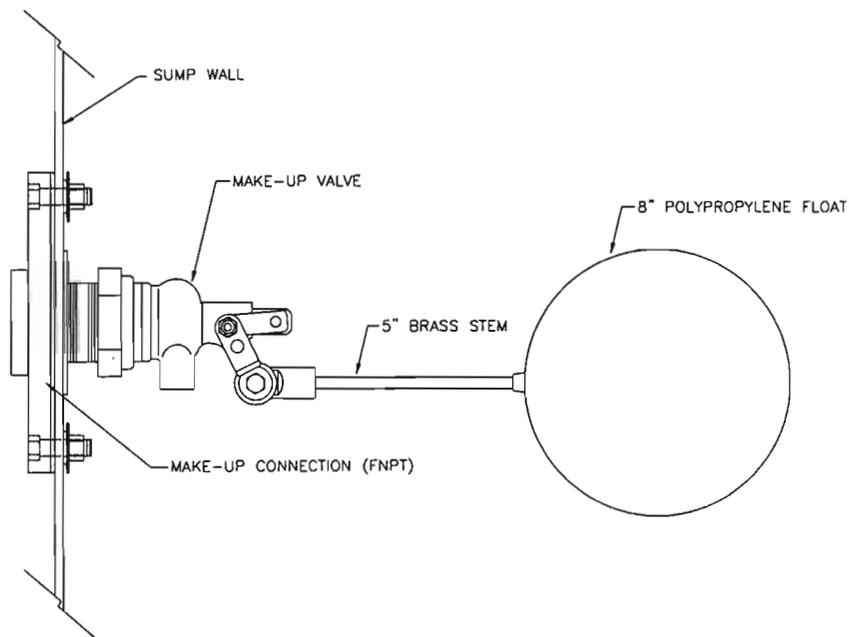


FIGURE II-3.2: Typical Tower Make-Up Valve

B. Equalization/ Overflow Connection

The equalization/ overflow connection is located on the front of the sump in the lower right hand corner. This connection is either a 4" or 6", depending on tower size, and is a 150# flange. This line is used for two purposes, therefore it is important to pay special attention to piping instructions. It is especially important to note below in Figure II-3.3 the location and layout of the siphon breaker. This integral part of the overflow line prohibits the tower from being siphoned dry by allowing air to reenter the piping system once the water level lowers.

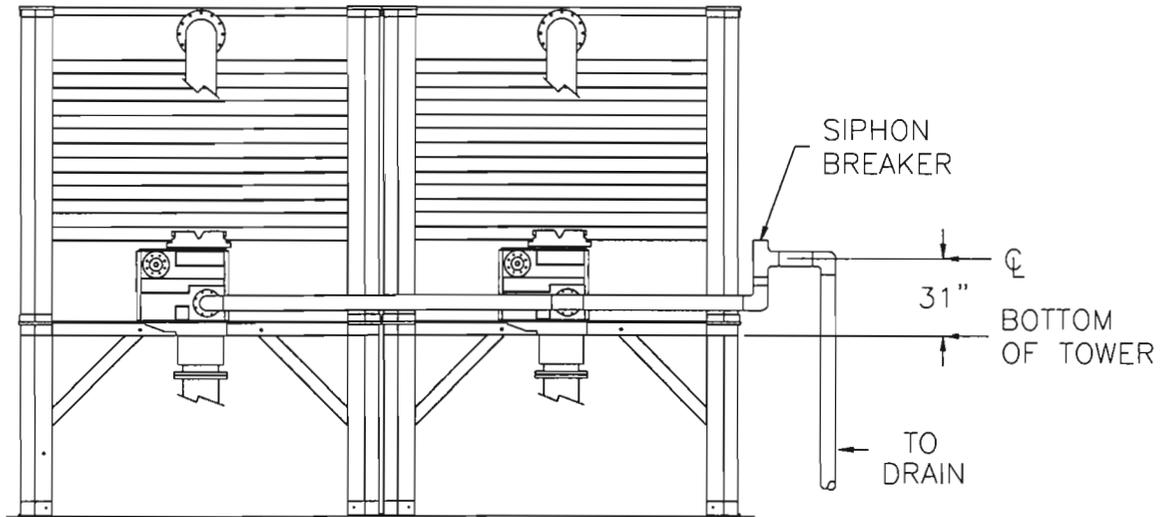


FIGURE II-3.3: Typical Equalization / Overflow Piping Layout

Piping between equalization flanges on multiple-tower installations provides some degree of basin equalization when flows to and from tower modules is not balanced. This line also provides a focus for overflow water to leave the towers. This line is designed to handle small water overflow problems (e.g. stuck make-up valves), and not as means to handle gross piping errors. Specific details are discussed in the *Operations* section.

C. Discharge Connection

The cold water return line exits from the bottom of the sump. Flanges are available in sizes from 8 inches through 14 inches, and are all 150# flanges. The suggested sizes that are listed in Table II-3.1 were chosen to maintain cold-water pipe velocities under 6 ft/s at nominal flow rates.

4. MECHANICAL EQUIPMENT

A. Fans

Crowley Company's X-Series Multiwing fan assemblies are used on all fiberglass TTMT series towers. The fan blades are made of high-strength, fiberglass-reinforced polypropylene. These are held in place by a die cast aluminum-silicon alloy hub. The high-efficiency fan blades can be set at any angle to allow for minimum power consumption. Crowley Company balances the fan blades on a Balmac 3000 Single Plane Balancer. Minimum balancing tolerances are based on ISO balancing standard TC/108, DR 1940. A G 6.3 balancing grade is used.

Three different fan assemblies are used, depending on tower model. These are listed in Table II-4.1 and depicted in Figures II-4.1 through II-4.3.

TABLE II-4.1: Fan Assemblies

Horsepower	Fill Type	Number of Blades	Blade Pitch	Blade Type
3	All	4	24	7x
5	All	4	32	7x
7.5	1900	8	28	7x
7.5	3800 & 5000	6		9x

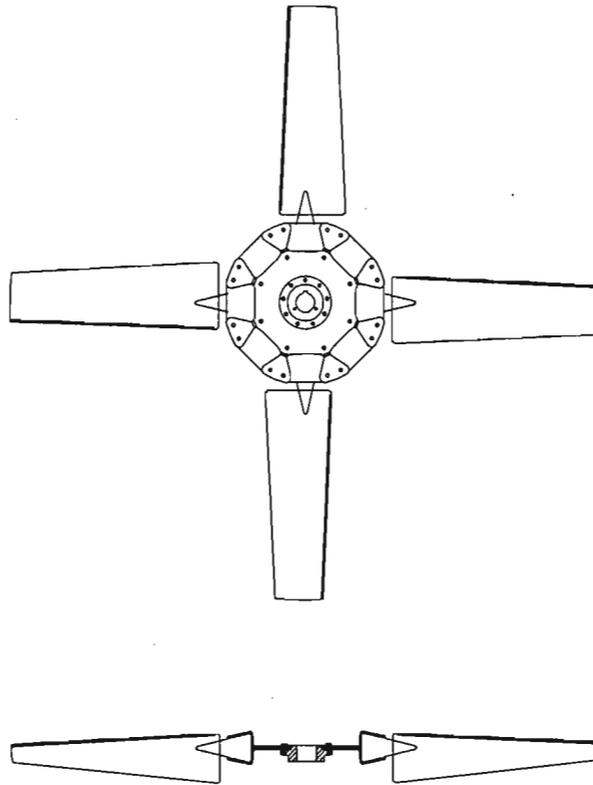


FIGURE II-4.1: Four-Bladed 7X Fan Assembly

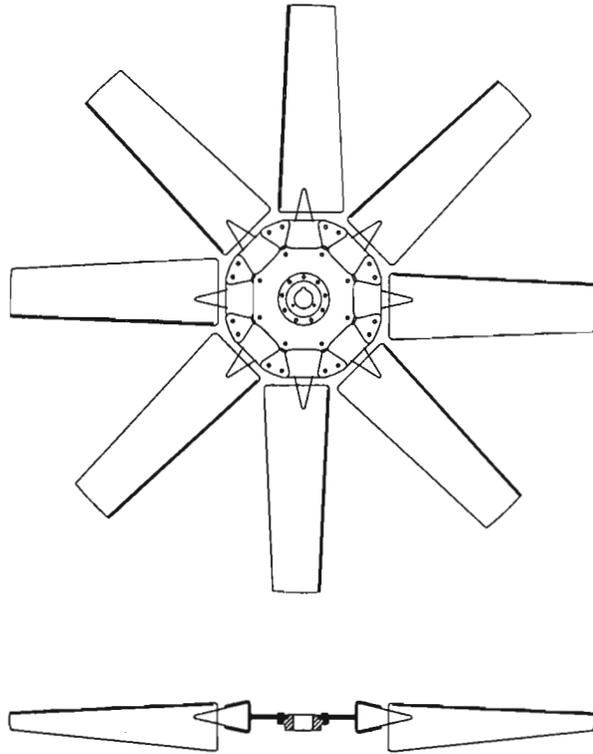


FIGURE II-4.2: Eight-Bladed 7X Fan Assembly

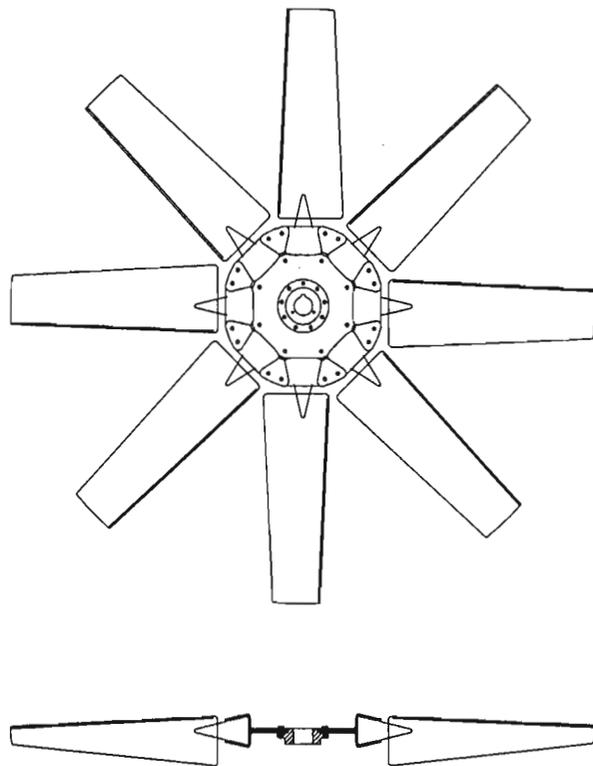


FIGURE II-4.3: Six-Bladed 9X Fan Assembly

B. Fan Shroud / Fan Guard

The fan shroud used on the TTMT Series of modular cooling towers is made from chopped fiberglass to provide a smooth transition for the air entering the fan, increasing the efficiency of the fan assembly and thus reducing energy costs. Because of the fiberglass construction, the shroud is very lightweight and will resist corrosion indefinitely. An illustration of the design of the fiberglass fan shroud is shown below in Figure II-4.4.

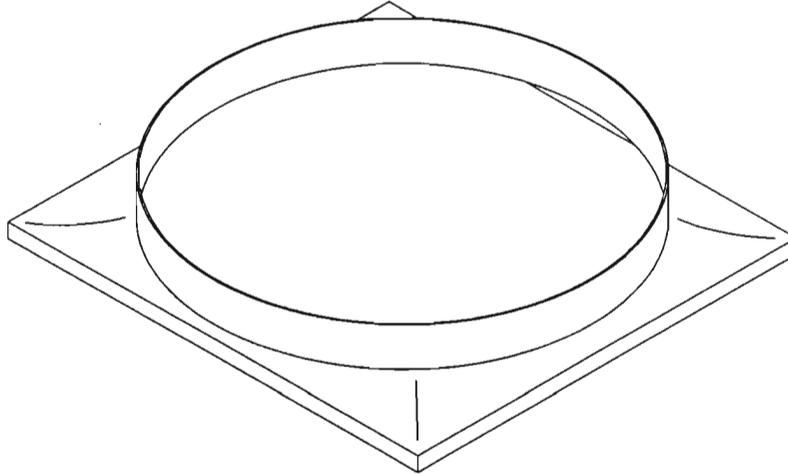


FIGURE II-4.4: Chopped-Fiberglass Fan Shroud

C. Motors

The standard motors on the TTMT Series of modular cooling towers are high efficiency US Motors. The motor sizes vary from 3 HP, 5 HP, to 7.5 HP, depending on the heat load requirements. All motors use the same 213T frame size and are TEAO (Totally Enclosed Air Over). Motors from other manufacturers may be used, however, increased cost and long lead times are normally associated with such changes. Check with your Tower Tech Representative for more information. Table II-4.2 lists information pertaining to US Motor's line of three-phase electrical motors used as standard in the TTMT modular cooling towers.

TABLE II-4.2: Standard US Motor Data

MOTOR DATA						
HP	Volts	Amps	Efficiency	Power Factor	Service Factor	# of Fan Blades
3.0	460	5.6	82.5%	61.0%	1.15	4
	230	11.2	82.5%	61.0%	1.15	4
5.0	460	8.5	82.7%	67.0%	1.15	4
	230	16.9	82.7%	67.0%	1.15	4
7.5	460	12.5	82.7%	68.1%	1.15	8
	230	24.9	82.7%	68.1%	1.15	8

Tower Tech passes on the 5 year warranty on the standard US Motors. Check with a Tower Tech Sales Representative about the details of this warranty.

D. Tower Electrical

TTMT modular cooling towers are prewired using THHN #12 or #10 wire from each motor to junction box or optional lock out disconnects. All wiring is routed using schedule 40 rigid EPVC conduit and NEMA 4X EPVC junction boxes. An illustration of the wiring system for a TTMT-144 Series modular cooling tower is shown Figure II-4.5 below. All other tower sizes will be similar.

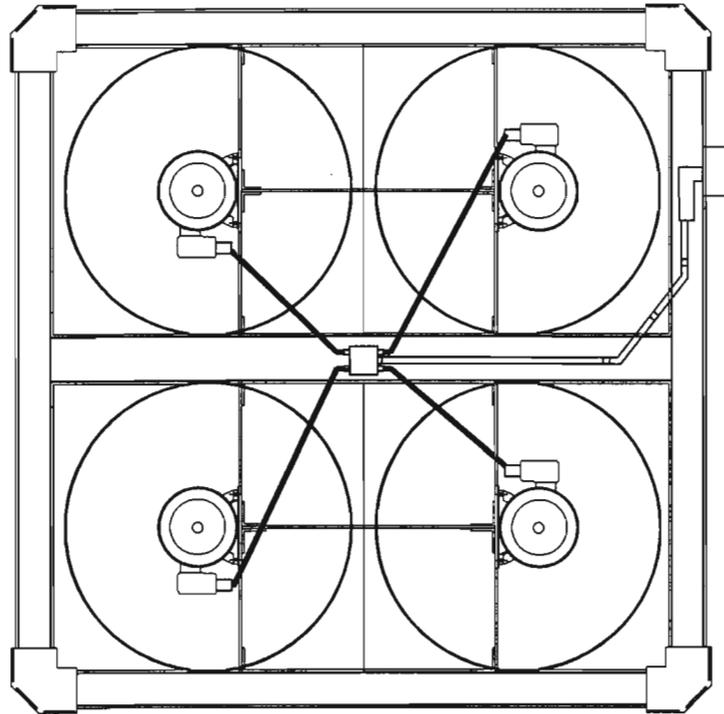


FIGURE II-4.5: Typical Tower Wiring Layout

The lockout disconnects are NEMA 4X fiberglass enclosures with rotary disconnect switches and auxiliary contacts for remote monitoring. This disconnect is shown below in Figure II-4.6.

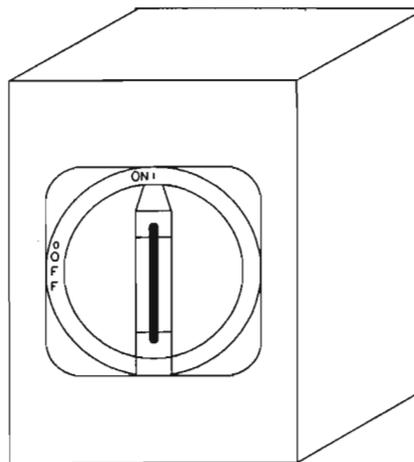


FIGURE II-4.6: Lockout Disconnect Switch

5. OPTIONAL EQUIPMENT

A. Fiberglass Substructure

Tower Tech offers a pultruded fiberglass substructure, shown in Figure II-5.1, that has been certified for seismic zone 4. This substructure is made from the same material as the tower corner closure panel to insure a long and maintenance-free life. This structure anchors via glass-reinforced nylon foot pads directly to piers or concrete slabs and connect to each corner of the module. Braces attach to the perimeter beam, providing rigid substructure support.

As a general rule, increases in leg height will improve tower performance. Higher leg heights should be used if obstructions reduce the airflow to the tower. However, excessive leg heights should be avoided. Six foot substructures are commonly used. For larger towers, placement of the TTMT tower on short legs that mount to a raised platform is the preferred method of installation.

Each substructure kit includes:

1. Pultruded fiberglass leg beams (standard lengths are 4 feet, 6 feet, or 8 feet)
2. Attached foot pad
3. Angle braces
4. All necessary stainless steel hardware to assemble.

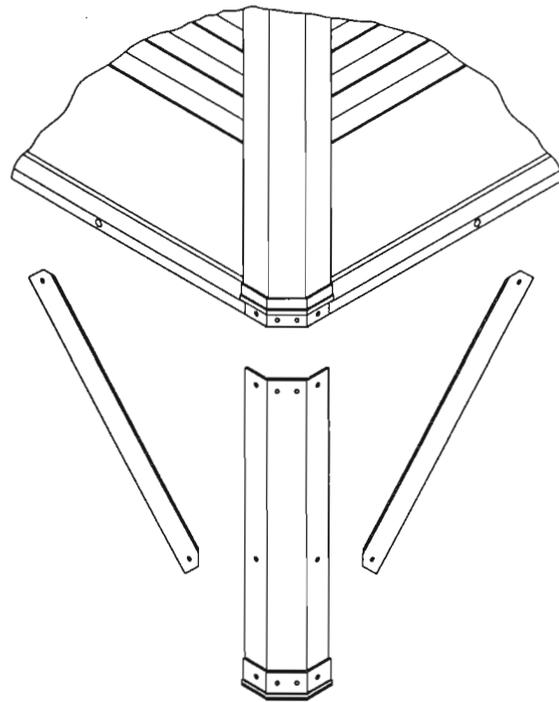


FIGURE II-5.1: Tower Substructure

B. Motor Starter Panel

Tower Tech offers a complete line of motor control accessories designed for the TTMT Series cooling tower.

Temperature Control / Starter Panel

The starter panel is equipped with a main disconnect capable of being locked in the “Off” position, and from one to twenty motor starters (depending on the number of modules being served). Each motor may be operated independently or in pairs. In multi-cell installations, it is more economical to operate the same number of fans in each tower module than to operate all fans in a single module. Each starter is pre-wired to the motor to reduce field labor costs.

This system can be regulated by a multi-point temperature controller (sold separately) and is the most energy efficient method of operating the tower since the fans will turn on or off to maintain a desired water temperature setpoint.

Tower Tech's motor control panels come complete and are ready for immediate installation. Panels only requires main power feed to the main disconnect switch and connections to the prewire junction box or motor disconnects. Typical panel placement is on a wall next to the tower or can mounted on unistrut supports under the tower. **Panels are never to be mounted on the tower structure. This will cause leakage or wall component failure.**

The panels are standard with individual HOA's, fusing, starters, overloads, and control circuits. NEMA 4X is the standard option but NEMA 3R can be ordered for indoor use. Auxiliary contacts and many other options are available for alarm monitoring or building automation control interfacing. An illustration of the Tower Tech motor control panel is shown below in Figure II-5.2.

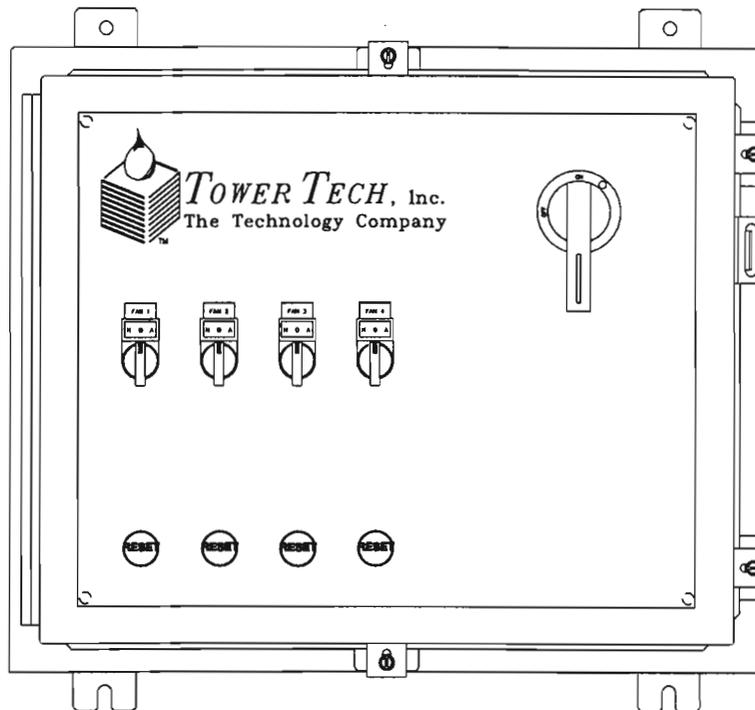


FIGURE II-5.2: Typical Motor Control Panel

Tower Tech supplies a complete schematic with all control panels. Custom panels and tower wiring requirements are designated a custom job number for easy identification. Standard wiring used in all towers using 460 volts is THHN #12. Changes such as 230 volts require THHN #10 or wiring called for by local electrical codes.

Temperature Control Unit and Sensor

The standard water temperature controller is the Tower Tech TT-X62.0 multi-point control unit. This unit comes preprogrammed from the factory to maintain a set point of 84.0 F but can be readily changed to any desired set point. The TT-X62 can also perform many other energy saving functions such as set point reset based upon outside air temperature. The TT-X62 is custom made for Tower Tech by Landis and Staefa. Tower Tech also has a complete line of programmable and or LAN devices to interface with existing building control systems.

C. VFD (Variable Frequency Drive)

Tower Tech offers the complete line of Safronics and Baldor variable frequency drives and solid state starters. The use of a VFD provides the tightest temperature control, 0.5 F is typical in most applications. Combining the use of a VFD with staged starters can further enhance process temperature control. The VFD will speed up or slow down the fan or fans as required to maintain a constant temperature.

D. Basin Heaters

Tower Tech offers an optional basin heater for winter operation. The standard is an Indeco Series 874-X stainless steel basin heater. Both 3 kW and 9 kW versions are available. The control unit is the Solitech Series TL combination Controller preset to 45.0 F. This unit can control up to four basin heating units. **However, all heaters must be located within the same water basin as the temperature sensing probe to prevent the possibility of fire.**

Tower Tech offers a pre-engineered package for the TTMT Series cooling towers. Each package includes:

1. Standard Stainless Steel electric immersion heater (Copper available)
2. UL listed control panel in NEMA 4 enclosure
3. Water level and temperature sensor
4. Wiring diagram
5. Installation and operating instructions

E. Vibration Switches

It is Tower Tech's philosophy that the fiberglass line of modular cooling towers does not require vibration switches because of the motor size and rugged design of the tower.

There is a serious potential for injury associated with the resetting of vibration switches that are located on the tower fan assemblies. An individual must reach through the fan blades to reset the vibration switch. An individual could lose their arm and possibly their life if power to the tower has not been turned off.

However, Tower Tech does offer a vibration sensitive switch for shutdown of the modular unit electrical equipment if specified by the customer. The switch uses a magnetic latch to reduce wear on the internal tripping mechanism and has a weather proof case. Towers must be fitted with a remote method of resetting the vibration switch to ensure that the reset process does not offer a potential for injury. Specific properties include;

Case: Weatherproof aluminum alloy construction.

Switch: SPDT, double make contacts. Rating: 5A at 480 VAC.

As an alternative, Tower Tech recommends the use of rubber "chiller" pads for isolation purposes.

F. Pump Packages

Centrifugal pumps are available for nearly any situation and can be custom built to meet any specification. Tower Tech offers Paco pumps in a variety of sizes. Four packages are available.

Package #1 includes: Pump, base, coupling and guard and ODP motor.

Package #2 includes: Pump, base, coupling, guard and TEFC motor.

Package #3 includes: Pump, base, coupling, guard, motor and skid.

Package #4 includes: Pump, base, coupling, guard, motor, skid and electrical panel that is prewired and ready to install.

G. Water Treatment

WATERwatch™ program

Optimum water treatment is crucial in maximizing equipment longevity and assuring peak tower efficiency. Tower Tech's WATERwatch™ program is recommended for all Tower Tech tower installations. This fully integrated, total systems approach to cooling water quality management has been developed specifically with the Tower Tech design in mind. The WATERwatch™ program encompasses a full line of chemical treatment compounds, including the AQUA-SHIELD line of corrosion and scale inhibitors, AQUA-SPERSE line of inorganics dispersants/bio-dispersants, AQUA-GUARD closed loop treatment and a full line of biocides. Also included is full field service support and in-house technical support, customized test kits and operating manuals, full line of chemical controllers/plc's, water meters, pumps, wet chemistry analyzers, deposition monitors and corrators. See a Tower Tech representative for more details on how WATERwatch™ can help you realize the water and chemical treatment savings engineered into the Tower Tech design.

Routine Operation

1. Tower recirculating water quality should be measured on a daily basis for the following parameters: Alkalinity, Hardness, pH, chlorine, inhibitor level (can be monitored indirectly through the use of a tracer or tag compound) and Total Dissolved Solids. Daily monitoring is essential to assuring that the tower and downstream equipment are not subject to deleterious system upsets. System monitoring using these parameters is key to assuring that scaling inefficiencies or damaging corrosion is NOT occurring. Appropriate polymer and phosphonate blends are recommended for control of scaling. Limiting scaling component should be determined from the make-up water chemistry and appropriate formulation selected.
2. Tower blowdown may be controlled by conductivity or TDS (Total Dissolved Solids). Use of pH control is also critical in assuring that system pH remains within an optimal range, namely pH 7.9 - 8.2. Optimum pH is critical in controlling scaling, corrosion, as well as, assuring the optimum conditions for biocidal effectiveness. Consult your Tower Tech representative for details on our full-line of controllers and plc's which can regulate chemical metering and system cycles of concentration.

3. Tower should NOT be operated without the use of a proven biocidal treatment regime. Legionellae are ubiquitous in water, can multiply in a cooling tower to hazardous levels, then be disseminated in drift where susceptible passers-by may become infected. Eradication of Legionellae from tower systems is not practical, hence the goal is to control their proliferation via biocides. Current experts recommend the combination of an oxidizing biocide (fed continuously) with a non-oxidizing biocide (intermittently applied), as well as, the use of a biodispersant to control biofilm formation. Consult your Tower Tech representative for details on our complete line of biocides and AQUA-SPERSE biodispersant effective for bio-film and pathogen control. In addition if tower has been removed from operation for a length of time (e.g. seasonal or plant shutdown) a rigorous cleaning should be administered as well as hyper-chlorination. Tower should be treated with 15 ppm residual chlorine which is recirculated only through tower system for a period of at least two hours. The chlorinated water should be drained and the tower refilled with fresh water and returned to the established water treatment program.

Process Leaks

In the even of an oil or hydrocarbon leak it is recommended that the tower system be completely drained and then refilled with water. Water should be treated with a heavier than normal level of dispersant designed specifically for oil contaminants. After several hours of recirculation (with fans in off position), tower system should be drained then refilled with fresh water again and returned to the established water treatment program. Consult a WATERwatch™ representative for compatible dispersants.

H. Bernoulli Basin

The benefits of Tower Tech's raised/enclosed basin are well known, reduced pump head and water treatment costs. The "internal" basin was designed with minimum capacity so that tower performance is not adversely affected. Since multiple-tower configurations are linked with an equalization line, the towers can share basins if they are started and shutdown in a logical sequence. Starting (or shutting down) the towers in sequence allows the basins to equalize and gives the makeup (evaporation) time to equilibrate the towers.

In some cases, it is not possible to sequence the towers. As well, some plants have excessive overhead piping or machinery that requires extra water on start-up and added basin capacity on shutdown. Tower Tech has designed an alternative to large and expensive concrete basins for these additional-capacity jobs, the Bernoulli Basin.

The Bernoulli Basin is an external tank that is sized to fit the specialized needs of the job. The basin takes its name from the prolific Swiss mathematician, Daniel Bernoulli, who was instrumental in developing the well-known relationship between pressure and velocity in a fluid, Bernoulli's equation:

$$p + \frac{1}{2} \rho V^2 + \rho g z = C$$

The Bernoulli Basin is a small diameter tank that provides extra water to the process piping through a large drop in water elevation. The large elevation drop is accomplished by resourcefully employing the low pressure that exists in the cold-water return piping from the tower. The tank, piped to a "T" on the return line, adds water to the system based on the pressure at the "T". As the flow to the tower is increased, more water is held up in the fill. Concurrently, the pressure in the cold-water pipe drops and additional water is pulled from the Bernoulli Basin. This design allows the tower water level to remain relatively constant as flows to the tower vary. A typical Bernoulli Basin installation is shown in Figure II-5.3 below.

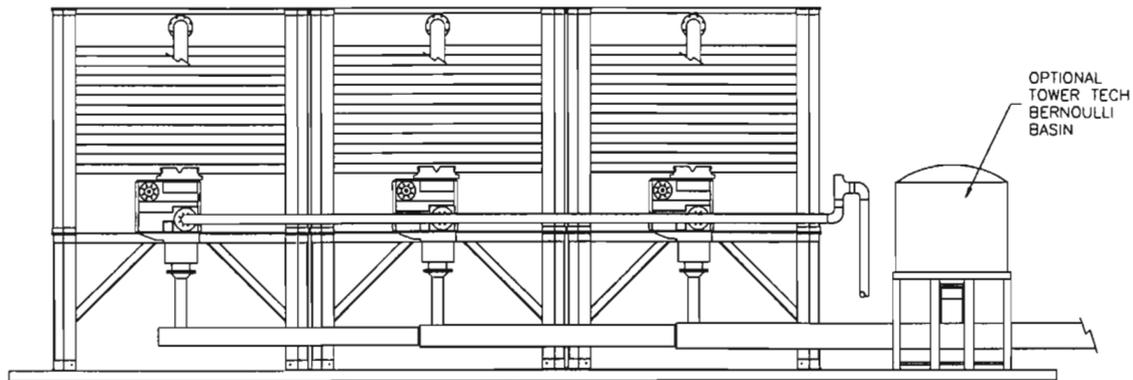


FIGURE II-5.3: Typical Bernoulli Basin Layout

SECTION III

TOWER SELECTION AND SPECIFICATION

1. TOWER SIZING

- 1) Calculate design inlet wet bulb.

$$\text{Design inlet wet bulb (F)} = \text{Design ambient wet bulb (F)} + \text{recirculation allowance (F)}$$

- 2) Calculate design range.

$$\text{Range (F)} = \text{Hot water (F)} - \text{Cold water (F)}$$

- 3) Calculate design approach.

$$\text{Approach (F)} = \text{Cold water (F)} - \text{Inlet wet bulb (F)}$$

- 4) Calculate design heat load.

$$\text{Design heat load (BTU/h)} = \text{Water flow (US GPM)} \times \text{Range (F)} \times 500$$

- 5) Calculate design load.

$$\text{Design heat load (BTU/h)}$$

$$\text{Design Load} = \frac{\text{Design heat load (BTU/h)}}{15,000 \text{ (BTU/h/ton)}}$$

- 6) Determine module nominal tonnage.

The module nominal tonnage is the capability, expressed in tons of refrigeration, at 78° F entering air wet bulb temperature. Read this nominal tonnage on charts 1 to 5, as a function of range (calculated at step 2) and approach (calculated at step 3). Interpolate linearly if necessary.

- 7) Calculate module actual tonnage at design inlet wet bulb.

To find the actual module tonnage capability (when the entering air design wet bulb is different for 78° F) multiply the module nominal tonnage by the following factors:

INLET BULB	WET	MULT. FACTOR	INLET BULB	WET	MULT. FACTOR	INLET BULB	WET	MULT. FACTOR
58		0.66	67		0.79	76		0.96
59		0.67	68		0.81	77		0.98
60		0.69	69		0.83	78		1.00
61		0.70	70		0.85	79		1.02
62		0.72	71		0.87	80		1.04
63		0.73	72		0.89	81		1.06
64		0.75	73		0.90	82		1.09
65		0.76	74		0.92	83		1.11
66		0.78	75		0.94			

8) Correction for altitude.

When the tower is located at more than 1,000 foot altitude, multiply the sea level actual tonnage, found at step 7, by the following correction factors:

ALTITUDE FT	MULTIPLYING FACTOR
1,000	1.007
2,000	1.014
3,000	1.022
4,000	1.030
5,000	1.038
6,000	1.047
7,000	1.057
8,000	1.067
9,000	1.077
10,000	1.087

9) Determine number of modules.

$$\text{Number modules} = \frac{\text{Total design load (tons)}}{\text{module capability (ton/module)}}$$

2. DISK OF DATA TABLES

TOWER TECH, INC.

MODULAR TOWERS SERIES TTMT

CORRECTION CHARTS

Capability Correction Versus Air Inlet
and
Number of Modules

Base Range 10° F

Base Approach 7° F

Base Wet Bulb 78° F

Air Inlet Velocity <1,200 FPM

3. TOWER SPECIFICATION

GENERAL

Furnish and install, a direct forced draft, counterflow, factory-assembled, modular concrete cooling tower. Overall dimensions shall not exceed _____ feet long by _____ feet wide by _____ feet overall height. The tower shall be a minimum of _____ cells and shall be Tower Tech Model Number CONCRETE-_____. The structure shall be of pultruded concrete of premium isophthalic polyester resin and must have a flame spread rating less than 25. Each module must be capable of operating independently or in combination with other modules.

PERFORMANCE

The tower shall have the capacity to cool _____ GPM of circulating water from _____ °F HWT, to _____ °F CWT, at _____ °F entering wet bulb temperature.

STRUCTURE

The cold water basin and the casing shall be constructed from a pultrusion process that utilizes a premium isophthalic polyester resin with UV inhibitors and shall be a minimum thickness of ¼ inch.

WATER COLLECTION SYSTEM

The tower shall utilize a water collection system positioned beneath the fill media and above the air inlet that will collect the cold water and permit the mechanical equipment to be mounted into the dry air stream underneath the cooling tower. The water collectors shall be made of molded plastic material.

MOTORS

There shall be _____ motors at _____ horsepower per motor for a total horsepower of _____. The motors shall be 230/460 volt, 3 phase, 60 Hz, TEFC, _____ RPM, single-speed, single winding. Maximum brake horsepower shall not exceed _____ horsepower.

MECHANICAL EQUIPMENT

Fans shall be _____ blade propeller type with an air efficiency rating not lower than _____%. The fan motor shall be mounted to a concrete sub-structure with stainless steel bolts. Metal mechanical supports will not be accepted. The tower shall have _____ direct drive fans per cell. The fan assembly and motor shall be located outside the moist air stream. Towers utilizing gear reducers or belt driven units will not be accepted. A corrosion resistant mesh guard to prevent entry of airborne objects into the fan is required.

WATER DISTRIBUTION SYSTEM

Water shall enter the tower through an enclosed, low pressure, Polyvinyl Chloride (PVC) header and lateral piping system. Water shall be evenly distributed over the fill media by evenly spaced and sized polypropylene rotary spray nozzles. The nozzles shall have a four inch orifice for clog free operation, produce a square pattern, and shall be located no more than three inches above the fill media. The nozzles must operate between a minimum ½ pound pressure and a maximum 1½ pounds pressure.

FILL AND DRIFT ELIMINATORS

Fill shall be cross-fluted film type, PVC material, impervious to decay, fungus and biological attack. Fill sheets shall be self-spacing, supported on maximum spans of 7 inches. The fill shall be performance tested by the cooling tower manufacturer to provide single source responsibility and assure control of the final performance. Drift eliminators shall be minimum three-pass PVC material of cellular design impervious to decay, fungus and biological attack. Drift losses shall not exceed .005% of the design circulating flow.

**TOWER SPECIFICATION FORM
(SUBJECT TOWER)**

SHEET 1 OF 3

Customer:	Manufacturer:
John Doe Company	Tower Tech, Inc.
PO Box 0000	Post Office Box 1838
Anywhere, USA 00000	Chickasha, OK 70323
Inquiry No. 1001-1002	Proposal No. 022494-RC30
Date: 9/21/92	

All data set forth herein is in accordance with definitions and standards published by the Cooling Tower Institute.
Symbol * = minimum information to be filled-in by customer, other items may be specified at customer's option.

General:	
Selection	Forced draft
Tower Model	CONCRETE-288-119
Type	Counterflow
Design & Operating Conditions:	
*Circulating Water Flow, U.S. GPM	10,000
*Hot (Inlet) Water Temp. F.	104
*Cold (Outlet) Water Temp. F.	89
*Wet Bulb Temp. F., Inlet	78
Ambient	
Tower Pump Head, Ft.	13'
Total Fan B.H.P., (Driver Output)	110
Drift Loss, % of Circulating Flow	.005
Evaporation Loss (at design)	132.80 GPM
*Design Wind Load, Lbs./Sq. Ft.	30
Mi./Hr.	100
*Design Seismic Load, %G	Code
*Tower Site (Ground Level, Roof, Etc.)	Ground
*Elevation Above Sea Level, Ft.	1000'
*Tower Exposure.	Unobstructed
Structural Details:	
Number of Cells	5
Fans Per Cell	8
Total Number of Fans	40
Nominal Cell Dimen., L X W, Ft.	24 X 12
Overall Tower Dimension, L X W, Ft.	60' x 24'
Height - Support Pier to Tower Top, Ft.	10' 6"
Overall Tower Height, Ft.	16' 6"
*Column Extensions, Perimeter, Above Grade	6'
Internal Above Grade	6'
Anchorage	18-8 Stainless Steel

**TOWER SPECIFICATION FORM
(SUBJECT TOWER)**

SHEET 2 OF 3
INQUIRY NO: 1001-1002
PROPOSAL NO: 022494-RC30

Structural Details (Contd.)	
Hot Water Inlet - Number	5
Nom. Diameter, In.	10"
Description	Enclosed Low Pressure
Height Inlet Above Basin Curb, Ft.	9' 6"
access to Top of Tower	N/A
Shipping Weight, Lbs.	11,162 # Each Cell
Operating Weight, Lbs.	23,583 # Each Cell
Materials of Construction	
Framework Members	FRP
Casing	FRP
Filling	PVC
Support	FRP
Drift Eliminators	PVC
Spacer	PVC
Fan Stacks	FRP
Louvers, Material	N/A
Partitions	FRP
Fan Deck.	N/A
Water Distribution - Type	Enclosed Low Pressure
Material	PVC
Splashers or Spray Nozzles	Polypropylene
Bolts, Nuts, Washers (motor only)	18-8 Stainless Steel
Anchor Connectors	18-8 Stainless Steel
Mechanical Equipment Support	FRP
*Anchor Bolts - Material	18-8 Stainless Steel
Furnished By	Customer
*Support Piers - Material	
Furnished By	Customer
*Basin Accessories, by Mfg.	
Mechanical Equipment:	
Fans	
Number	40
Type or Model	TT4.75 Adjustable Pitch Blade
Manufacturer	Crowley or equal
Diameter, Ft.	4' 75"
Number of Blades	4

**TOWER SPECIFICATION FORM
(SUBJECT TOWER)**

SHEET 3 OF 3
INQUIRY NO: 1001-1002
PROPOSAL No: 022494-RC30

Mechanical Equipment (Contd.)	
Fans	
Fan Speed, RPM	900
Tip Speed, FPM	12,725
BHP per Fan, Driver Output	2.9
Blade Material	Concrete Reinforced Polypropylene
Hub Material	Aluminized Cast Aluminum - Silicon Alloy
Total Static Pressure, in. H2O	.685
Velocity Pressure, in. H2O	.084
Air Delivery Per Fan, ACFM	18,508
Fan Static Efficiency	70.0
Speed Reducer	
Number	N/A
Type	
Model	
Manufacturer	
Reduction Ratio	
AGNA Mechanical H.P. Rating	
Service Factor at Rated H.P. of Driver	
No. of Reductions	
Drive Shaft	
Number	N/A
Type	
Model	
Manufacturer	
Rated H.P.	
Drive Shaft Material	
Coupling Material	
Driver	
Number	40
*Kind	Electric
*Type	TEFC
Manufacturer	Lincoln or equal
Full Load Speed, RPM	870
*Elec. Char. - Phase/Cycles/Volts	3/60/460
Rated H.P.	3.0
Additional Data	

SECTION IV

INSTALLATION

1. TOWER LOCATION

The best place for a cooling tower is on a roof by itself. However, when this is not possible, these layout guidelines must be followed to provide a satisfactory installation. The position of the unit with respect to other structures must be considered. The top of the cooling tower must be higher than any adjacent walls, buildings or other structures. When the top of the unit is lower than the surrounding structures, as in Figure IV-1.1, recirculation can be a major problem. If the unit is on the windward side as shown in Figure IV-1.2, the discharge air will be forced against the building, causing a majority of the moist air to proceed over the building, reducing any recirculation effects. Although this positioning does not place the top of the tower above the surrounding structure, it can be a very simple way to greatly reduce recirculation. It is highly recommended, however, that whenever possible, the tower be raised at or above the level to the surrounding structure. This is the only sure way to minimize recirculation effects, and improve tower performance.

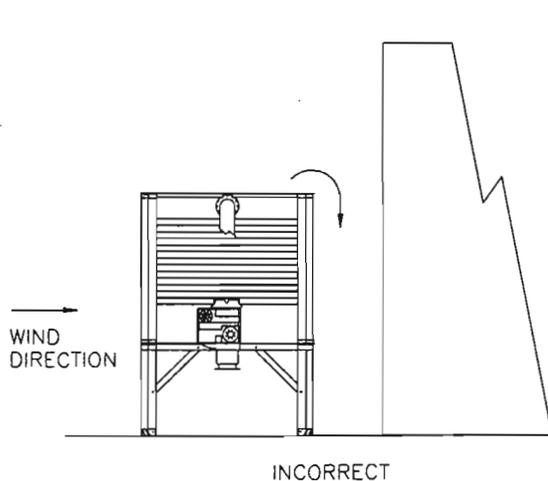


FIGURE IV-1.1

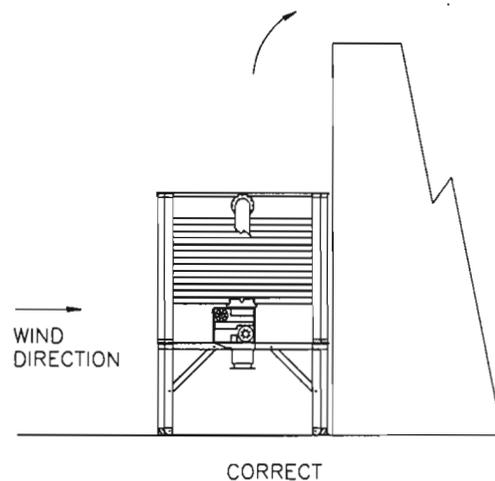


FIGURE IV-1.2

When the wind comes from the opposite direction, the resulting negative pressure area created by the wind passing over the building will cause the discharge air to be forced back into the inlets per Figure IV-1.3. The simple method to correct this problem is to elevate the unit so that the top of the tower is higher than, or at least level with, the wall. An illustration of this is shown in Figure IV-1.4.

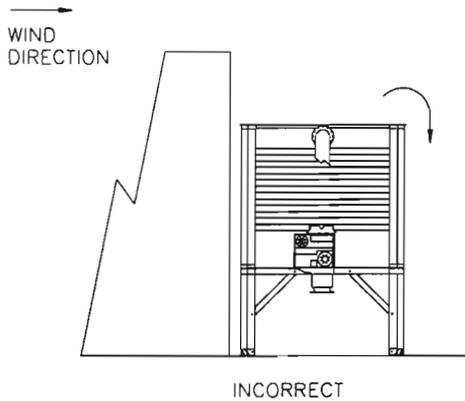


FIGURE IV-1.3

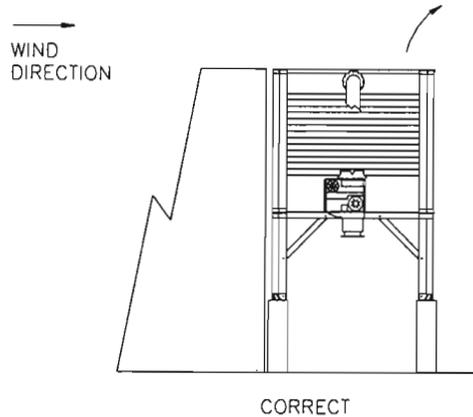


FIGURE IV-1.4

2. TOWER INSTALLATION

A. General Safety

All tower operations must be performed as specified by a site specific safety plan, which is the responsibility of the customer. Questions may be directed to Tower Tech, Inc. Safety Department at 405-222-2876.

B. Precautions

1. Always use good safety practices.
2. Never lift tower or any equipment over personnel.
3. Always use lifting equipment properly sized for the unit being lifted.
4. Only qualified experienced personnel should perform rigging.
5. Never stand directly under equipment that is being lifted.
6. Always inspect lifting lugs and lifting equipment for damage.
7. Never use damaged hardware.
8. Do not lift in high wind situations.

NOTICE:

Lifting a tower that has been in service is especially hazardous. Prior to lifting in this case, inspect cooling tower fill media and water basin for sediment build-up. This build-up could cause the tower to exceed weight limitations that the lifting lugs were designed for. Some or all of the fill media may have to be removed to reduce the weight to a safe level. If in doubt, contact Tower Tech, Inc. Service Department at 405-222-2876 for advice.

3. RIGGING

A. Method of Shipment

TTMT Series cooling towers are shipped on flatbed trailers. When possible, the towers should be lifted directly from the trailer to the final point of installation to minimize rigging changes. Tower support structure, sump, and sump hardware are located on the tongue of the trailer.

B. Tower Lifting and Placement

1. Unstrap cooling tower from trailer. The tower should be strapped at each corner. Remove tower substructure, sump, and angle braces, if any, from tongue of trailer. Open sump box and check for proper hardware. Hardware included INSIDE of sump should be as follows:

TABLE IV-3.1: Supplied Tower Hardware

TOWER PARTS LIST *		
	Quantity	Description
Substructure Kit	16	1/2" X 2 1/2" Bolts
	16	1/2" Nuts
	32	1/2" Flat Washers
	4	Legs With Pre-installed Footpads
Angle Brace Kit (If Equipped)	16	1" X 2 1/2" Bolts
	16	1" Nuts
	32	1" Flat Washers
	8	5" X 5" X 1/2" Angle Braces
Sump Kit	22	1/2" X 2" Bolts
	22	1/2" Nuts
	44	1/2" Flat Washers
	4	3/8" Nuts
	8	3/8" Flat Washers
	8	3/8" Neoprene Washers
	2	Fiberglass Backing Plates
	1	Split Ring Flange
	1	Rectangle Sump Gasket
	1	Round Split Ring Gasket
1	Tube Silicone	
Heater Probe Kit (If Equipped)	1	Heater Control Junction Box
	1	Heater Probe

* Located inside of sump

2. Inspect cooling tower lifting lugs (located at top of tower) for cracks or loose hardware.
DANGER. Do not lift a tower with cracked or loose lifting hardware. If repairs are required, consult Tower Tech, Inc. personnel for instructions.

3. Position crane directly over tower module using one cable for each lifting lug. Secure a cable to each lifting lug by means of an adequately rated clevis. Reference Figures IV-3.1 and IV-3.2, and Table IV-3.1 below for lifting procedures and tower specifications. Recommended cable lengths, and or I-beams, must be used to eliminate side loading of tower panels. Extreme side loading can result in leakage caused by broken seals, permanent bending of tower structural members, or ultimate failure of the tower casing panels.

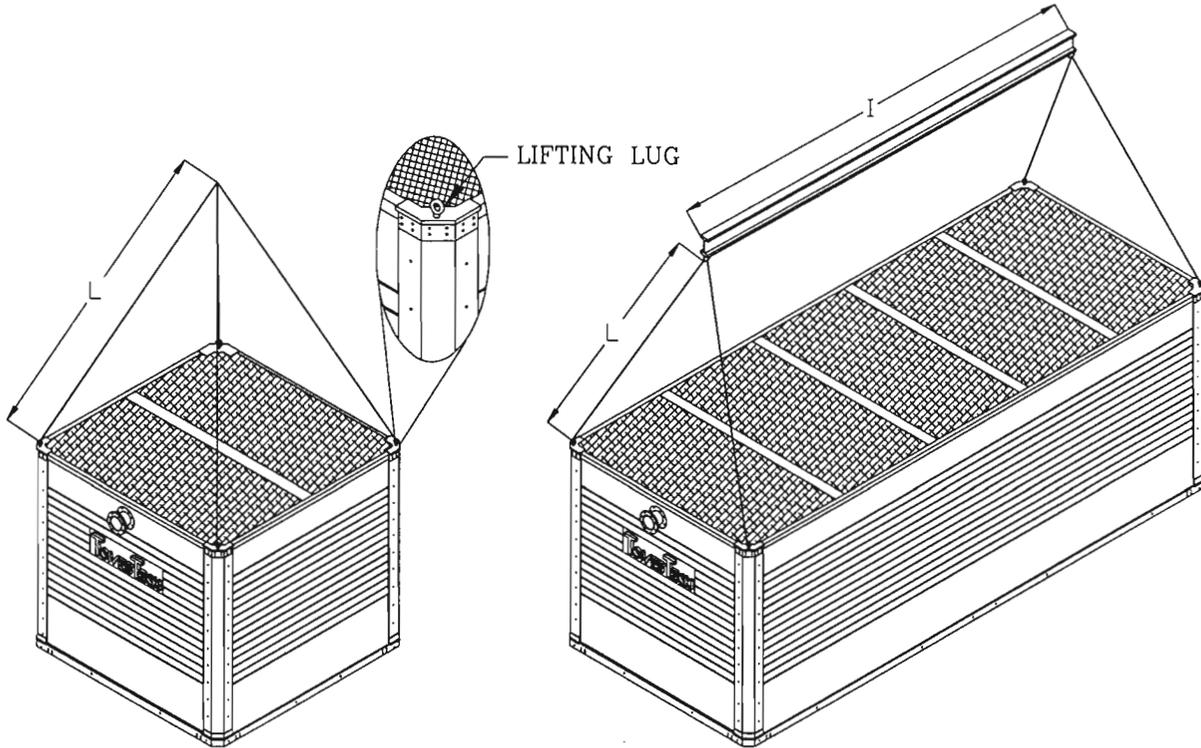


FIGURE IV-3.1: Standard Tower Lifting Procedure

FIGURE IV-3.2: TTMT 360 Series Lifting Procedure

TABLE IV-3.1: Tower Lifting Data

TOWER SERIES #	WEIGHT* LBS	L FT	I FT
TTMT-36	4,500	8	-
TTMT-72	5,600	10	-
TTMT-108	6,700	15	-
TTMT-144	7,800	15	-
TTMT-216	10,000	20	-
TTMT-288	12,200	25	-
TTMT-360**	14,400	15	24
TTMT-360	14,400	25	12

* Tower Weights Vary Based On Optional Equipment, Residual Water, Etc.
Weights Listed Are To Be Used As Guidelines Only.

** Recommended Tower Lifting Procedure

4. Connect a guide rope to the bottom of the cooling tower. This will allow personnel to position the tower without standing under the suspended module.

5. Lift module from trailer and move into position keeping module as close to the ground level as possible. **UNDER NO CIRCUMSTANCE SHOULD THE TOWER BE LIFTED OVER ANY PERSONNEL.**

WARNING: Prior to lifting tower, check for residual water that may remain in the lower basin panel. Remove any excess water before lifting tower. Excess water in basin can drastically increase tower weight, causing failure to tower lifting mechanism.

6. Position tower into place near final destination.

7. Loosely attach substructure kit, with angle supports if included, to the tower at each corner using the provided substructure bolt kit (See Table IV-3.1).

8. Lower tower into position on the pre-installed anchor bolts. Once all anchor bolts are in position on the footpads, start the nuts, but do not tighten.

9. Once all the anchor nuts are started, tighten the substructure bolts on the tower, followed by the angle support bracket bolts. Each of these bolts should be tightened to approximately 90-100 ft-lbs.

10. After tightening all the substructure and angle support bolts, tighten the anchor nuts using large surface flat washers.

11. Once all bolts are securely fastened, check overall stability of tower, substructure panels, and angle braces. Verify that tower is level and stability is adequate for operation.

12. Disconnect crane from lifting lugs.

4. PIPING INSTRUCTIONS

A. Piping Design

Many of the problems with the water level in the enclosed basin can be attributed to poor cold-water piping. High velocities in the tower's exit piping generates high dynamic pressures with resulting low static pressures. These low pressures create an effect similar to that encountered in the Bernoulli Basin. The low pressures in the return header can literally suck a tower dry. Equalization lines do little to rectify this problem. To minimize these difficulties, make certain that the cold-water piping is sized to keep velocities below 6 ft/s. Velocities of 5 ft/s or less are preferred.

B. Sump Attachment

After completion of rigging it is necessary to install the tower sump before piping can be performed. Figure IV-4.1 and IV-4.2 shows the procedure outlined below.

1. Clean sump flange surfaces of any debris.
2. Apply silicone provided to both sides of the rectangular sump flange gasket.
3. Place rectangular gasket onto tower side of sump flange and insert two bolts from the inside of sump at top corners through the gasket to insure proper alignment.
4. Install a flat washer and neoprene washer to the four factory-assembled sump spacer bolts, in order as shown in Figure IV-4.1 below. This figure shows the entire procedure for installing the sump spacer bolts and fiberglass backing plates, however refer to step 9 for details.

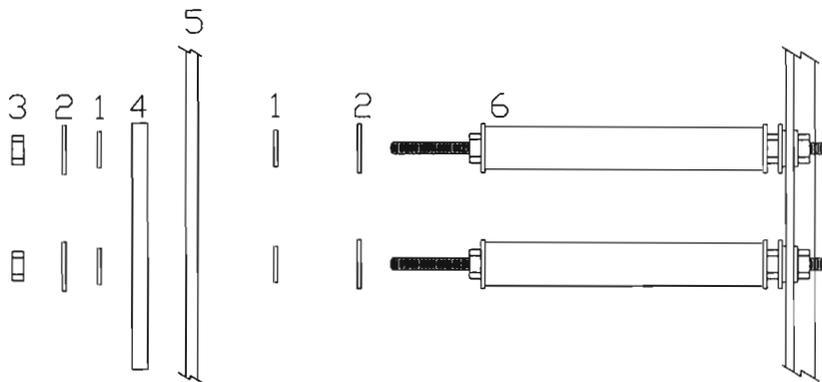


FIGURE IV-4.1: Sump Spacer Bolt Arrangement

- Where:
- 1 - 3/8" Neoprene Washer
 - 2 - 3/8" Flat Washer
 - 3 - 3/8" Nut
 - 4 - Fiberglass Backing Plate
 - 5 - Sump Wall
 - 6 - Factory Pre-assembled Sump Spacer Bolt

5. Lift the sump into position to be bolted onto tower.
6. Align the sump to the tower by using the two bolts that were placed in the sump flange. In conjunction with these two bolts, align the four sump spacer bolts (factory-attached threaded spacer) into the corresponding holes in the sump.
7. Push the bolts to the inside of the tower using a flat washer and nut. Hand tighten until snug. The procedure for installing the sump is illustrated in Figure IV-4.2. For details on the installation of the sump spacer bolts and fiberglass backing plates, refer to Figure IV-4.1.

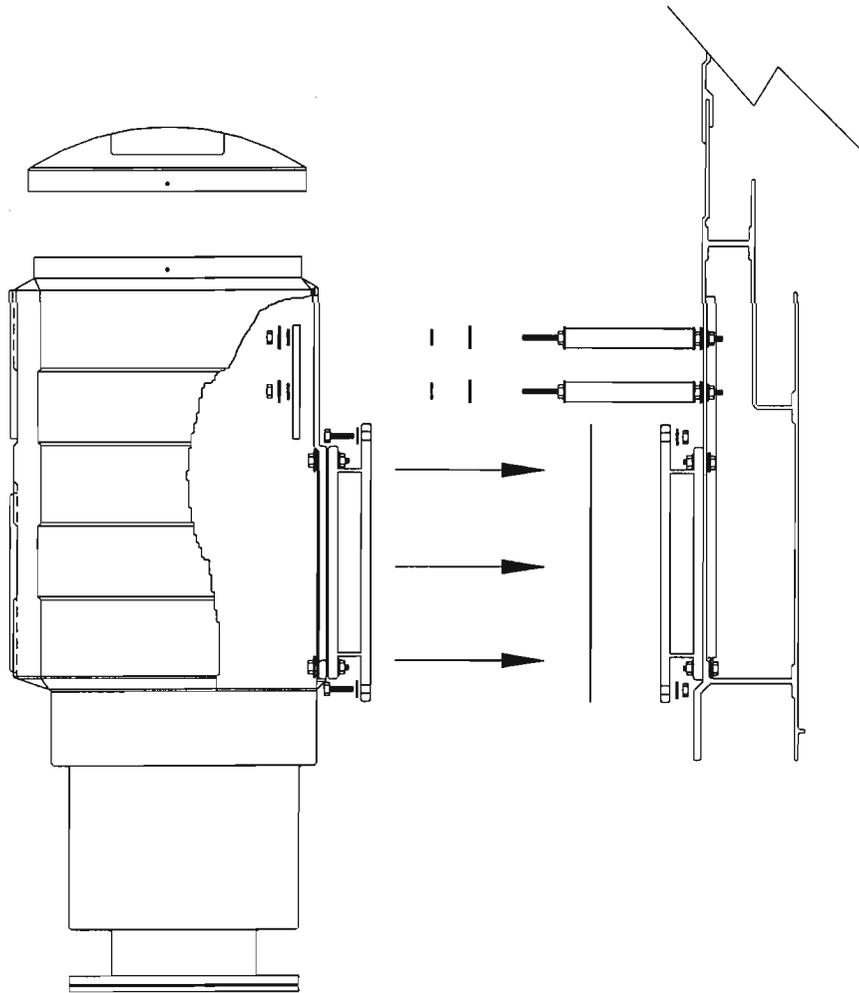


FIGURE IV-4.2: Sump Attachment Procedure

8. Install the remaining bolts through the sump, using flat washers and nuts as shown, into the tower and tighten evenly to approximately 35-45 ft-lbs.
9. Coat the fiberglass backing plates with silicone, place them onto the sump spacer bolts and press against sump wall. Place a neoprene washer, flat washer, and nut onto sump spacer bolt as shown in Figure IV-4.1. Tighten the spacer bolt nuts to approximately 25-30 ft-lbs. As an extra barrier against leakage, it is recommended that a coating of silicone be applied over the nuts and threads of the sump spacer bolts.

C. Piping Connections

The TTMT Series of modular cooling towers come with a variety of piping connections. It is very important that the guidelines herein be followed as closely as possible to insure that no damage to the unit occurs. An overall illustration of the major connections used when installing the tower is shown below in Figure IV-4.3. A detailed description of each connection and its function are given below.

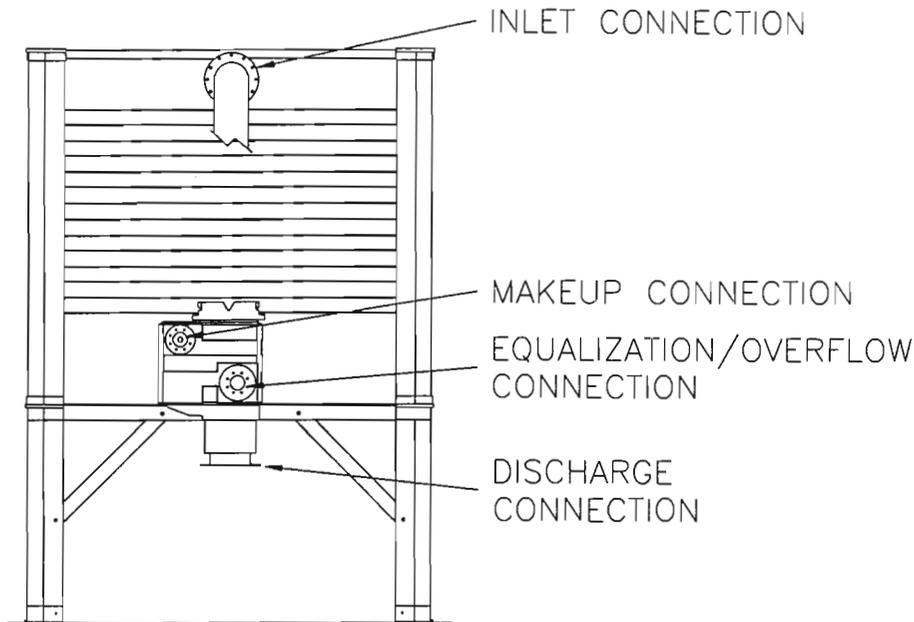


FIGURE IV-4.3: Piping Connection Locations

These connections are available in of configurations and sizes, depending on tower size, flow rates, and number of modules. Table IV-4.1 shows the standard flange connection sizes provided by Tower Tech. Whenever possible, these guidelines should be followed, so that piping velocities remain reasonable, and tower operational problems are not encountered.

TABLE IV-4.1: Pipe Connection Sizes

TTMT SERIES #	STANDARD PIPE CONNECTION SIZES			
	INLET	DISCHARGE	EQ. / O.F.	MAKE-UP
TTMT-36	4" 150#	8" 150#	4"	1" FNPT
TTMT-72	6" 150#	8" 150#	4"	1" FNPT
TTMT-108	8" 150#	10" 150#	4"	1" FNPT
TTMT-144	8" 150#	10" 150#	6"	1" FNPT
TTMT-216	10" 150#	12" 150#	6"	2" FNPT
TTMT-288	12" 150#	14" 150#	6"	2" FNPT
TTMT-360	12" 150#	14" 150#	6"	2" FNPT

Inlet

The TTMT Series cooling tower is designed so that water can be supplied from one of two sides to minimize the amount of piping. The inlet flange size depends upon the capacity of the tower, ranging from 4", 6", 8", 10", to 12". All flanges are 150# R.F. (Raised Face) VanStone type to aid in piping installation. Table IV-4.2 provides information regarding each flange connection size.

TABLE IV-4.2: Inlet Connection Flange Data

FLANGE SIZE	FLANGE TYPE	# OF BOLTS	BOLT DIAMETER	BOLT TORQUE
4"	150# R.F. PVC	8	5/8"	30-35 ft-lbs
6"	150# R.F. PVC	8	3/4"	35-40 ft lbs
8"	150# R.F. PVC	8	3/4"	35-40 ft-lbs
10"	150# R.F. PVC	12	7/8"	40-45 ft-lbs
12"	150# R.F. PVC	12	7/8"	40-45 ft-lbs

It is recommended that a valve be installed in the inlet piping to regulate the flow to each module. This procedure simplifies flow balancing to the towers, and provides a means to isolate single towers. It is very important not to overtorque the flanges, as damage or breakage may occur. A compatible gasket should be used between flanges to eliminate leaks.

NOTE: All Piping Shall Be Free Standing And Not Supported By The Cooling Tower!

Discharge

The cold water return line exits from the sump located at the bottom of the module. The flange sizes vary from one model to another, ranging from 8", 10", 12", to 14". All sizes are 150 # Flat Face flanges. A split ring is placed around the sump discharge lip, the bolt holes are aligned, and the piping flange is bolted using the round rubber gasket provided inside the sump. Table IV-4.3 provides information on the discharge flange connections.

TABLE IV-4.3: Discharge Connection Flange Data

FLANGE SIZE	FLANGE TYPE	# OF BOLTS	BOLT DIAMETER	BOLT TORQUE
6"	150# F.F. 18% Nylon	8	3/4"	35-40 ft-lbs
8"	150# F.F. 18% Nylon	8	3/4"	35-40 ft-lbs
10"	150# F.F. 18% Nylon	12	7/8"	40-45 ft-lbs
12"	150# F.F. 18% Nylon	12	7/8"	40-45 ft-lbs
14"	150# F.F. 18% Nylon	12	1"	45-50 ft-lbs

It is recommended that a valve be installed in the discharge piping to regulate flow to each module. This procedure, when used in conjunction with inlet valving, provides even greater flexibility in balancing the flows to multiple towers and allows the owner to isolate single towers if the need arises. The discharge flanges are NOT R.F. (Raised Face) flanges. It is very important to pay special attention to the torque recommendations, as overtightening can lead to flange warping or breaking.

NOTE: All Piping Shall Be Free Standing And Not Supported By The Cooling Tower!
Equalization / Overflow

The equalization / overflow connection is located on the front of the sump in the lower right hand corner. This connection is a 150# flange. The 6" overflow flange is a R.F. Vanstone type connection, whereas the 4" flange is a slip type PVC connection. A gasket should be used when using a 6" connection to eliminate leaks, and the 3/4" bolts should be torqued to 35-40 ft-lbs. This connection is used for dual purposes, therefore it is important to pay special attention to piping instructions.

In multi-cell installations it is necessary to use equalization lines, which serve as an extension of the overflow piping. In single-cell installations, there is no need for equalization, therefore this connection is only responsible for overflow needs. In all cases be sure that the overflow piping is at the specified level. See Figure IV-4.4 below. It is especially important to note the location and layout of the siphon breaker. This integral part of the overflow line prohibits the tower from being siphoned dry by allowing air to reenter the piping system once the water level lowers.

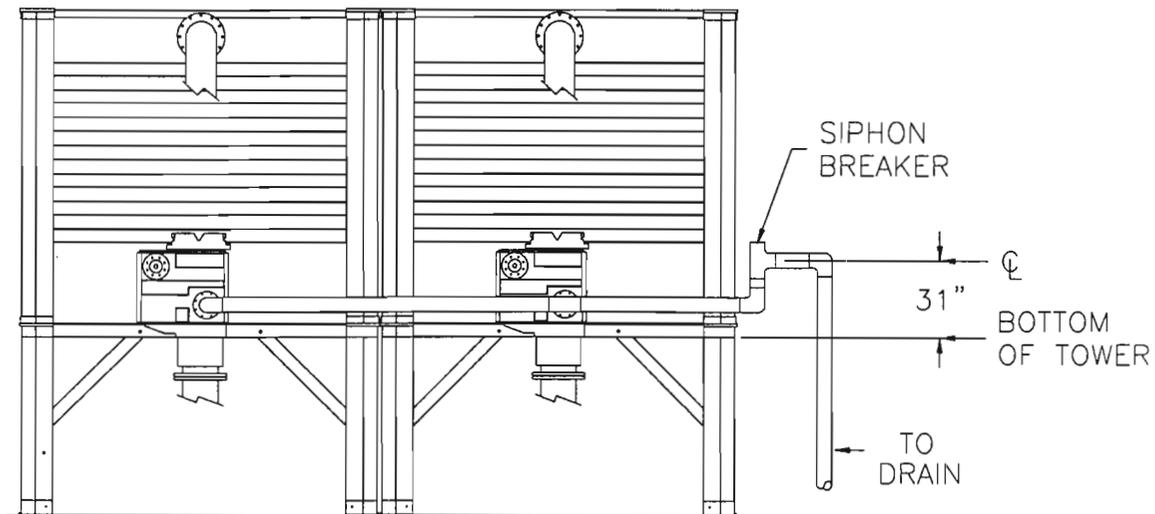


FIGURE IV-4.4: Typical Equalization / Overflow Piping Layout

Make-Up

The TTMT Series cooling tower is supplied with either a one or two inch brass float valve. The connection fitting is located on the front of the sump in the upper left hand corner. The fitting is Female Nautical Pipe Thread (FNPT). This valve is built to withstand the turbulence encountered in high-flow cooling tower applications. All valve components are made of either brass or stainless steel, providing corrosion resistance in this harsh environment. The connection flange is made from high quality ABS to eliminate corrosion. One inch FNPT connections should be torqued to 60-70 ft-lbs, and two inch FNPT connections should be torqued to 70-80 ft-lbs.

NOTE: All piping should be installed by qualified personnel who are familiar with local, state and federal regulations.

5. ELECTRICAL HOOK-UP

Tower Tech's modular cooling towers have motors that are prewired at the factory to eliminate field wiring. When specified, these motors are wired to a common junction box mounted on the tower. The end-user is then only responsible for the wiring to the junction box of the tower, greatly simplifying the wiring process, and reducing field labor costs associated with electrical connections.

A temperature control system can also be specified. This system integrates a temperature control into the motor starter panel, allowing for more energy efficient operation by allowing the fans to be staged when the system is only under part load conditions.

SECTION V

INITIAL START-UP

1. PUMP START-UP

1. Open make-up valve(s) and allow basin(s) and piping to fill.
2. Check water level in sump to assure proper float valve adjustment. The proper water level should be within the range, between +3 and -6 of normal operating level, specified in Figure V-1.1 below. Only in rare circumstances should the water level deviate from this specified range.

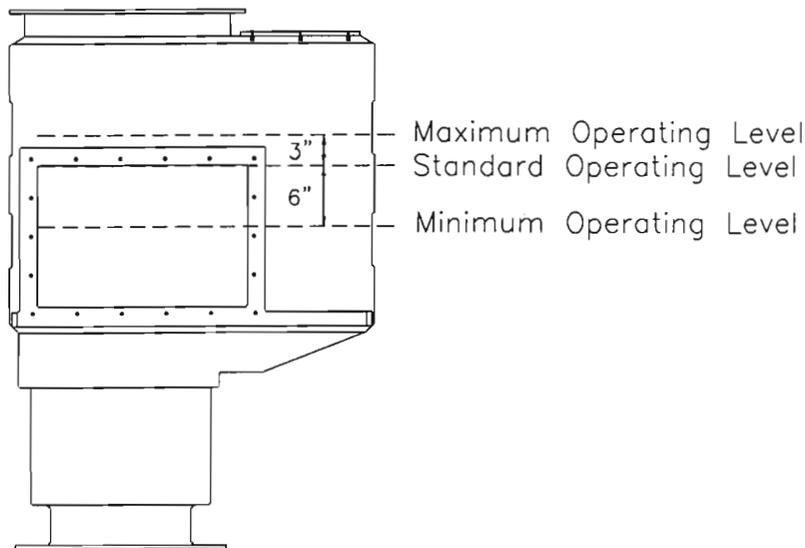


FIGURE V-1.1: Proper Operating Water Level

3. Check all flanged connections and piping for leaks.
4. Bleed air from piping by opening bleed valve at pump until water flows out in a steady stream without interruption. Close bleed valve.
5. Open valve(s) to cooling towers approximately twenty-five percent (25%).
6. Start pump.
7. Allow pump to run with valves open twenty-five percent (25%) until the make-up water has had time to replenish the water that is being removed from the basin.
8. After the basin level has risen to operating level, slowly open the valve(s) to the cooling tower(s) to the full open position.
9. Verify operating level in tower is within specified range after system has equalized.

2. FLOW BALANCING

In multi-cell installations it is often necessary to balance the water flow entering each cell or pair of cells. To view the water distribution, remove a section of drift eliminators from each cell. Flow balancing can be easily simplified by using valves in both the inlet and discharge piping systems of each tower, as recommended in *Piping Instructions* section. A typical flow balancing problem and its solution are given below using Figure V-2.1.

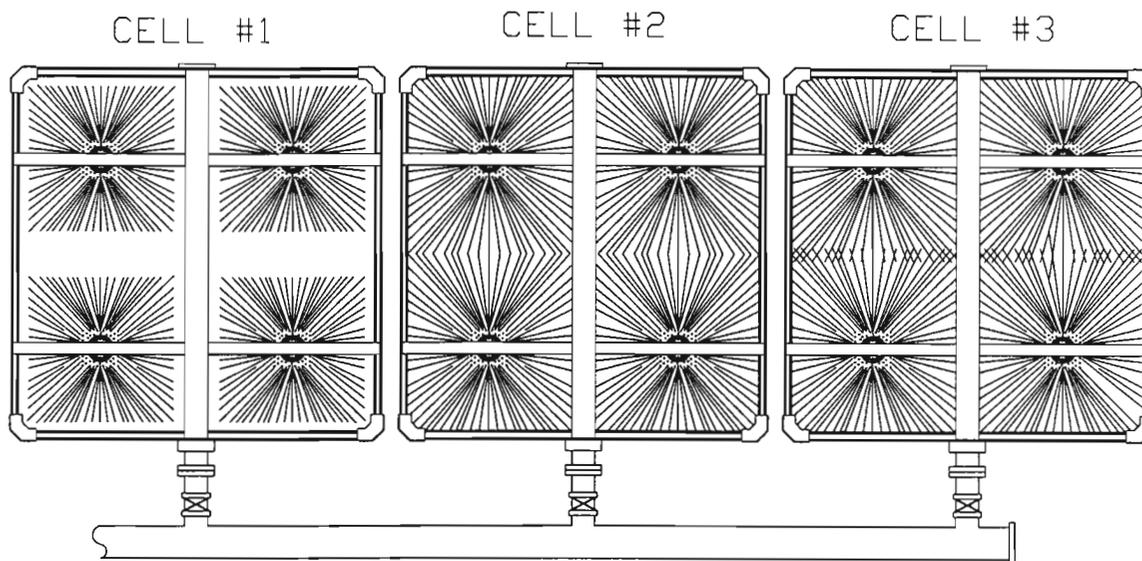


FIGURE V-2.1: Typical Flow Balancing Problem

Cell #1 does not have enough water flow.
Cell #2 has the correct water flow.
Cell #3 has too much water flow.

Solution: Close inlet valve to cell #3 slightly until cells #1 and #3 are like cell #2. It may then be necessary to readjust cells #2 and #3, however, start with the cell that has the heaviest water flow.

It is highly recommended that the flows to each tower be balanced using a flow metering device, such as an ultrasonic meter, as small variations in flow rates may not be visually detectable. These small variations, however, may not allow some towers to function properly, reducing the thermal performance of the system. Once all inlet valves have been adjusted so that each tower receives the same flow rate, some attention must be paid to the tower water levels, to insure they are consistent. In multi-cell installations, pressure differentials in the piping system may cause variations in the water levels of subsequent towers. To equalize these pressure differentials, some adjustments to the discharge piping valves, if equipped, may need to be made. By adjusting the discharge piping valves, the water levels can be equalized, eliminating variations in system performance. These adjustments, however, must be made by qualified personnel to insure tower performance is not jeopardized.

3. FAN START-UP

1. Before starting fans, visually inspect each fan for proper tip clearance of approximately one quarter inch ($\frac{1}{4}$ "). If clearance is insufficient, contact a Tower Tech Representative for information on solving the problem. In many instances, these problems arise as a result of shipping, due to uneven tower loading or binding occurring during rigging.

2. Make certain that all fan guards are secured in place.

3. Check for proper rotation of the fans by turning the fans on, then turning them off. The fans should be pushing the air upward. If rotation is incorrect, a qualified electrician should interchange two of the three phases to correct the rotation.

4. Start fans and measure the amperage to determine if the fan pitch is properly adjusted. The current should not exceed the name plate rating, given by Table II-4.2 in the *Motors* section. **Note:** In winter operation conditions or when the tower does not have a heat load applied, the current may run into the 1.15 service factor.

5. After checking all of the items listed above, the heat load can then be introduced.

**PLEASE DIRECT ANY QUESTIONS TO TOWER TECH SERVICE DEPARTMENT
AT 405-222-2876.**

SECTION VI

OPERATION

1. PERFORMANCE ENHANCEMENT

There are a number of procedures that can be followed in order to extract the maximum benefit from the TTMT Series of modular cooling towers. These procedures have herein been broken down into two basic groups, water control and air control, since these are the primary elements involved in the operation of any cooling tower. There are, however, some benefits that may be gained by controlling these two parameters in conjunction with Tower Tech's recommendations, that could not be accomplished with a conventional cooling tower, due to the unique design characteristics of the Tower Tech fiberglass cooling tower.

A. Flow Control

In many instances, benefits can be seen from controlling the water flow through the cooling tower circuit. Reduced pump head, reduced horsepower requirements, and subsequent energy savings are only a few of the benefits that can be realized from variations in total system flows. One of the most unique components of the Tower Tech design is the patented Rotary Spray nozzle. This nozzle makes it possible to provide a wide range of flow capabilities to the system. The design spray pattern for the Rotary Spray nozzle is based on a nominal flow rate of 250-300 GPM. It is, however, possible to operate the nozzle from 100-350 GPM, without any variation in spray pattern or distribution characteristics. The nozzle will perform at flow rates at or below 100 GPM, but a slight reduction in the pattern width will result. For these reasons, lowered flow rates, due to part load conditions, can be distributed to all towers, eliminating the need to shut down individual cells. This allows the entire fill media surface to remain wetted, increasing the efficiency of the system. By following some simple fan control procedures, listed below, even more benefit can be gained from this increase in efficiency, including reduced energy costs, and reduced fill media scaling. With proper water treatment, scale can be reduced, however, most fill media scaling occurs when the media is allowed to dry out. With the Tower Tech design, all of the fill surface area can remain wetted, thereby reducing scaling, and water treatment costs.

B. Fan Control

Benefits may also be obtained from controlling the fans on a cooling tower. With the Tower Tech design, each cell has a multitude of fans which can be staged on or off, depending on the load requirements. As stated above, when the total water flow volume is allowed to circulate through all towers in the system, there is an increase in efficiency associated with the use of the total fill surface area. This increase in efficiency allows the total fan horsepower to be further reduced. By staging off fans, and not entire cells, under part load conditions, the Tower Tech module can operate more efficiently. With a VFD, however, these part-load savings can be even greater. By using a VFD on all fans, the total required airflow is distributed through the entire cell. This efficient airflow distribution, coupled with superior water flow distribution, allows the Tower Tech module to operate very efficiently.

With part-load conditions occurring most of the time, energy savings associated with these conditions can prove very significant. In most instances, full-load conditions may occur for less than 10% of the year, providing only part-load conditions the rest of the year. Because these conditions constitute such a large portion of the total operating parameters, efforts to improve system efficiency during these periods can have significant pay-backs. Tower Tech has focused on these operating parameters in order to reduce the cost of operating the cooling tower system. Figures VI-1.1 and VI-1.2 below are used to graphically explain the significant energy savings associated with the Tower Tech design. With the ability to vary both water flow and airflow within a single cell, Tower Tech has provided the user with greater benefits in energy savings and maintenance costs.

Using a few simple equations, the total savings provided by the ability to vary tower water flow rate can easily be seen. First, it must be noted that tower performance, P, is proportional to the airflow velocity, V, multiplied by the tower area, A. This equation is given below. Next, the total horsepower requirements, HP, for the fan assembly are proportional to the number of cells, N, multiplied by the velocity cubed, V³. Under full-load conditions, the total horsepower requirements for the Tower Tech tower and a conventional tower design are the same, as shown in Figure VI-1.1. Under part-load conditions, however, the horsepower requirements for the Tower Tech design are 1/4 of those needed for the conventional tower design, as shown in Figure VI-2.1.

$$P \cong V \times A \quad \text{AND} \quad HP \cong N \times V^3$$

Tower operating parameters under full-load conditions are shown in Figure VI-1.1:

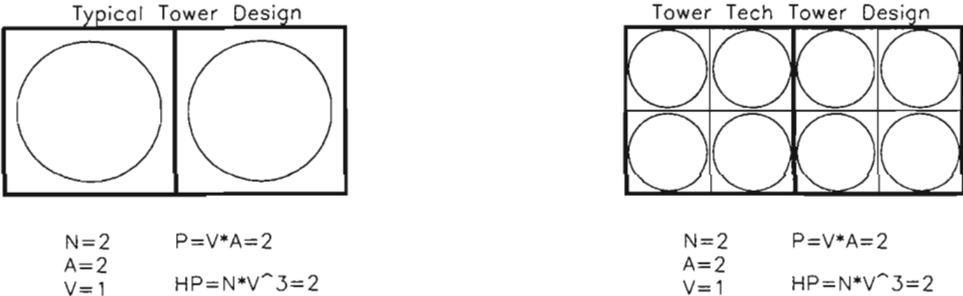


FIGURE VI-1.1: Full-load Tower Operating Parameters

Tower operating parameters under part-load conditions are shown in Figure VI-1.2:

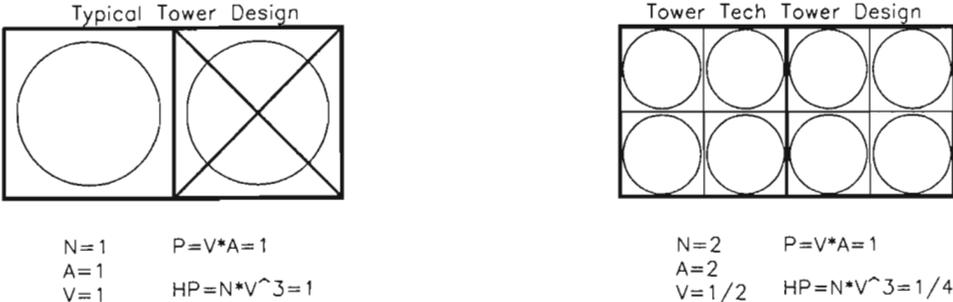


FIGURE VI-1.2: Part-load Tower Operating Parameters

As can easily be seen from Figure VI-1.2, the horsepower savings at part load conditions can be very significant with the Tower Tech design. In this instance, where the load, and thus the water flow, were reduced by half, the Tower Tech tower uses $\frac{1}{4}$ the horsepower of the conventional tower design. This is due to the fact that the air and water can be distributed over a greater area, and the horsepower required is a function of the velocity cubed. For these reasons, at any conditions other than full-load, a significant savings can be achieved using the Tower Tech design. To take advantage of these savings, however, the water flow must be controlled so that as pumps are turned off, the system flow continues to circulate through each tower module. A VFD also adds to these savings by allowing each fan to operate at a reduced RPM, thus incrementally lowering the velocity to any desired level.

Using some or all of the performance enhancements described above, the TTMT Series modular cooling tower can provide significant benefits to the end user. Tower Tech has minimized or eliminated most problems associated with conventional cooling towers. Since conception, Tower Tech has been committed to providing the best possible product to its customers. Innovations such as the ones described above have allowed Tower Tech to overcome many of the shortcomings of conventional towers. These benefits of design are the end product of countless hours of testing and development performed at the Tower Tech facility. The beneficiary of this intense development is the customer. Tower Tech is devoted to providing any information necessary so that the customer can operate the tower in the most efficient way possible.

2. WATER LEVEL CONTROL

The TTMT Series modular fiberglass cooling tower utilizes a float valve ranging in size from one inch to two inches. The valve is located in the sump and can be accessed by simply removing the sump lid. The valve is adjusted to the proper level at the factory. However, if the valve needs further adjustment, simply follow the instructions listed below to raise or lower the water level. Figure V-1.1 shows the recommended operating level, along with a maximum and minimum range for proper tower operation.

Adjusting Water Level:

1. Determine the proper water level. (See Figure V-1.1)
2. Turn water off which supplies float valve (if possible).
3. Remove make-up valve access lid.
4. Loosen adjustment bolt, but do not remove.
5. Rotate arm and stem for desired water level. (See Figure VI-1.1 below)
6. Tighten adjustment bolt.
7. Turn water on and verify water level is within range. (See Figure V-1.1)
8. Replace access lid.

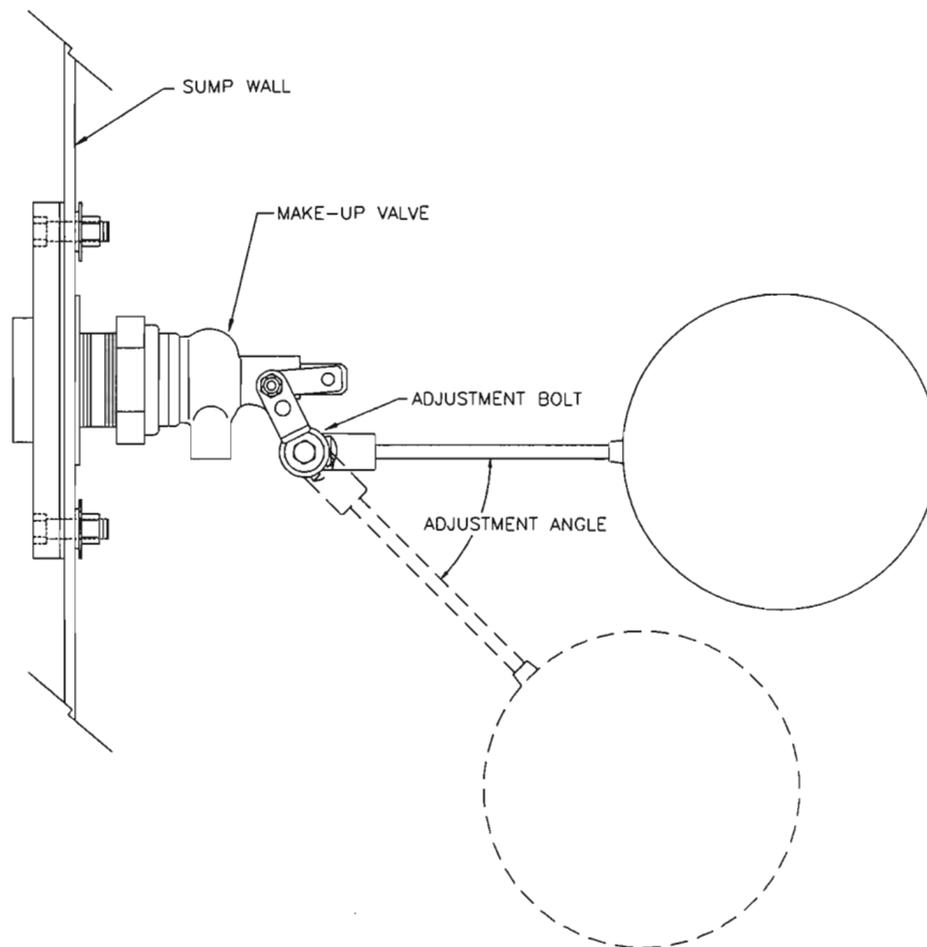


FIGURE VI-2.1: Float Valve Adjustment

3. ELECTRICAL TROUBLESHOOTING

4. TOWER ISOLATION

5. WINTER OPERATION

VFDs

All cooling towers have the potential to freeze during winter operations. As with other towers, Tower Tech's design requires a specific sequence of events to occur to optimize winter operations. It is imperative that the cold water exiting the collectors be maintained at a minimum of 40°F.

It is necessary to cycle towers off to remove ice from within the collectors. For high ambient temperatures (in the 20's), it takes more time to build up ice than when the temperatures are at extreme conditions (single digit and negative temperatures). Towers must be cycled off more frequently as the temperature falls and as cold water temperatures are reduced.

When cooling towers are not in service for any extended period of time the water should be drained. The drain valve should be left open to prevent rain or snow from collecting in the basin. When the cooling tower needs to be shut down for short periods such as overnight or on weekends, it is recommended that basin heaters be installed. These heaters should be programmed to turn on when the basin water drops to 40° F and should remain on until the temperature reaches 44° F.

SECTION VII

MAINTENANCE

1. MAINTENANCE SCHEDULE / INSTRUCTIONS

The TTMT Modular Fiberglass Cooling Tower is designed to require minimal maintenance. However the care it receives will greatly affect the life of the tower. The following schedule is given as a checklist to aid in providing the recommended inspection and maintenance.

- | | |
|-----------------------|-----------|
| 1. Surface | 6 months |
| 2. Drift Eliminators | 12 months |
| 3. Water Distribution | 12 months |
| 4. Fill Media | 12 months |
| 5. Fan Guards | Monthly |
| 6. Fans | Monthly |
| 7. Motors | 6 months |
| 8. Float Valve | 3 months |
| 9. Sump Screen | 1 month |

A. Surface Finish / Gelcoat

The TTMT Series modular cooling tower is constructed from pultruded fiberglass that has a gelcoat finish. The gelcoat finish protects the fiberglass from being damaged by ultra violet rays. The surface should be cleaned every six months. If blemishes or scratches are detected during cleaning and inspection, the areas affected should be cleaned thoroughly with solvent and touched up with fire retardant gelcoat. If scratches are not covered, the ultra violet rays of the sun can penetrate the concrete and greatly reduce the life expectancy of the material.

B. Drift Eliminators

The TTMT Series cooling towers utilize a low pressure three pass drift eliminator that is impervious to rot, decay or biological attack. There is an ultra violet inhibitor manufactured into the product to extend the life expectancy. These drift eliminators should be inspected once a year (in conjunction with the nozzle inspection). The drift eliminators should be free from any mud or debris that could build up. If the inspection reveals that cleaning is required, the following procedure should be followed to accomplish it.

1. Remove the cover on the concrete I-Beam that is bolted in the center of the cooling tower directly above the header.
2. Slide out the drift eliminators and place them gently on the ground.
3. Wash the eliminators by spraying with a low pressure water hose.
4. Turn the eliminators over and spray until remaining debris is removed.
5. Insert the eliminators back into place in the cooling tower.
6. Replace the fiberglass I-Beam cover to hold the drift eliminators in place.

C. Water Distribution

The TTMT Series cooling tower utilizes the Rotary Spray Nozzle. This nozzle has a large four inch orifice and a rotating disc that will dislodge nearly all debris. It is very unlikely that the nozzle will plug. Therefore inspection of the water distribution system is only necessary biannually to make certain of proper operation.

Inspecting the Rotary Spray Nozzle consists of visually inspecting the water distribution pattern. If sticks or large objects are jammed in the nozzle, follow the instructions below for removal.

To remove the Rotary Spray Nozzle:

1. Expose the nozzle by removing the drift eliminators that restrict access.
2. Remove the section of fill media that is directly below the nozzle.
3. Remove the small machine screw that locks the nozzle in place.
4. Using a strap wrench, unscrew the nozzle.

To install the Rotary Spray Nozzle:

1. Thread the nozzle back into the pipe until snug and the arrows on the nozzle are aligned with the pipe.
2. Thread the machine screw back into the nozzle to prevent the nozzle from loosening during operation.
3. Replace the fill media that was removed for working clearance.
4. Replace drift eliminators into position.

INSTRUCTIONS:

ROTARY SPRAY NOZZLE
WITH SPRING ASSEMBLY

PLEASE REFER TO FIGURE VII-1.1.

1. Insert 3/8" bolt through the baffle.
2. Insert bolt and baffle into the head of the nozzle and turn the baffle to a position that allows the baffle to drop down *below its design resting point*.
3. Slide the rotor into position with fingers pointing down.
4. Slide the bottom cap onto the bolt with Tower Tech label facing down.
5. Slide 3/8" washer onto bolt.
6. Slide spring onto bolt.
7. Compress spring on bolt. Then place another 3/8" washer on bolt and start 3/8" nut on bolt.
8. While holding down on the head, pull the baffle against the spring until the baffle can be turned and positioned in the *correct design point*.
9. Adjust the spring tension at this time by tightening the locking nut with a 9/16" wrench until the spring is compressed to 2¾".
10. The nozzle is now ready to re-install in the distribution system.

NOTE: Be certain that the baffle is aligned opposite the arrows on the head.

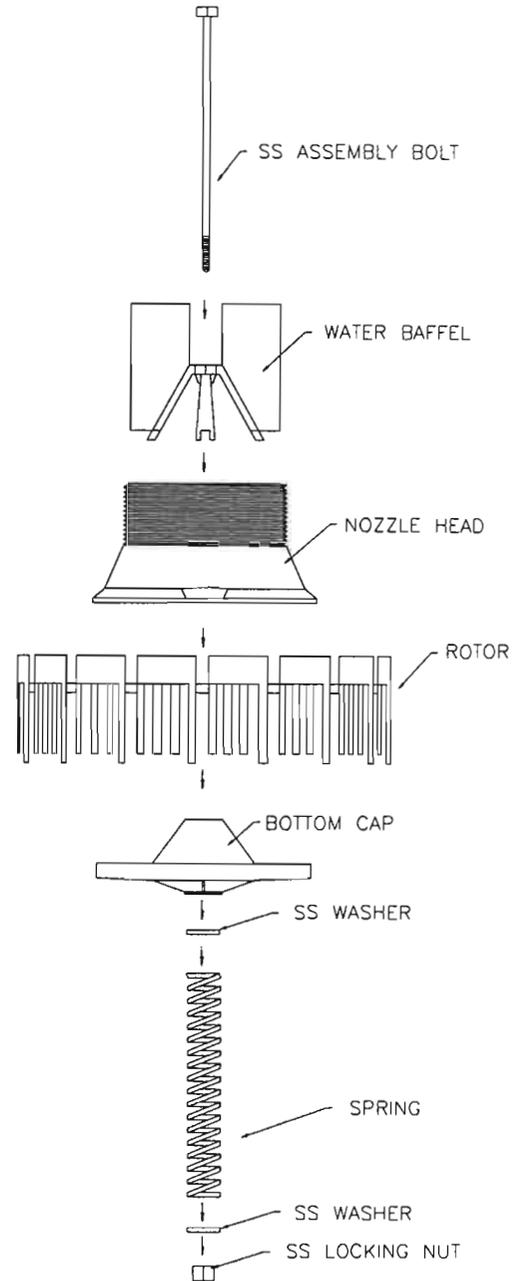


FIGURE VII-1.1: Exploded Nozzle

D. Fill Media

The fill media should be inspected on a regular schedule based on the quality of the water that is being circulated. With proper water treatment, the life expectancy of the fill media is approximately 15 years. The inspection should include removal of a randomly selected piece of fill chosen from the top layer. Visually inspect the opening in the bottom side of the piece to determine if any buildup of algae or mud is occurring.

If algae growth is detected, please contact your water treatment consultant to control the problem. If the buildup is significant, it may be necessary to remove the fill media and clean with a low pressure water and mild detergent.

To remove the fill media:

1. Remove drift eliminators.
2. Start removing the fill from the middle of the tower and work towards the side walls.
3. To prevent damage to the fill and water collectors, place three foot by three foot pieces of plywood in the cooling tower to stand on.

To install the fill media, reverse the procedure stated above.

E. Fan Guards

The fan guards are plastic coated to prevent rust and should not require maintenance. It is recommended that the guard be checked regularly for large items such as paper or leaves that might be sucked against the guard. It is important to the performance of the cooling tower that any air restrictions be removed.

To remove the fan guards:

1. Lock motor power in "OFF" position.
2. Loosen the bolts that are located around the perimeter of the guard.
3. After the bolts are loosened, push the bolt out and lower guard.
4. Place the guard on a flat surface (out of traffic area) to prevent damage.

To install the fan guards, reverse the procedure stated above.

F. Fans

The fans are pitched and aligned during assembly. There should be approximately 1/4" (one quarter inch) of tip clearance between the end of the fan blade and the edge of the fan shroud. Monthly inspections should be made of the tip clearance.

To remove the fan:

1. Lock out fan motor.
2. Remove the fan guard.
3. Remove the bolts from the fan bushing.
4. Thread the bolts back into the threaded holes that are provided in the bushing.
5. While supporting the fan, begin tightening the bolts into the bushing evenly until fan is pushed off the bushing.
6. While supporting the fan, tap the bushing gently off the motor shaft.
7. Lower the fan to the ground.

To install the fan, reverse the procedure stated above.

For instructions to change the pitch of the fan blade, contact Tower Tech Service Department at 405-222-2876.

G. Motors

To remove the motor:

1. Disconnect power and "lock-out".
2. Remove fan guard.
3. Remove fan.
4. Disconnect electrical wiring and conduit.
5. Loosen the four stainless steel bolts that connect the motor to the gusset and remove the shims making note of their placement.
6. Support the weight of the motor using a hydraulic lift or other lifting device.
7. Remove the connecting bolts while holding the motor steady.
8. Slowly lower the motor to the ground.

To install the motor, reverse the procedure stated above.

H. Float Valve

To remove the float valve:

1. Remove sump lid.
2. Remove thumb screw from valve assembly.
3. Using proper size wrench, unscrew the valve from the tank wall.

To install the float valve:

1. Attach valve to tank wall and connect valve inlet to water supply.
2. Valve outlet must be 90° to water level for bind-free operation.
3. Screw stem and float to short arm.
4. Rotate arm and stem for desired water level, tighten short arm thumbscrew.

2. SPARE PARTS

As with any system that is critical to the operation of a business, it is recommended that the customer maintain an inventory of tower spare parts to minimize equipment downtime. The recommended minimum inventory for most applications is present in Table VI-2.1 below. The customer, however, not Tower Tech, is responsible for selecting, purchasing, and maintaining the inventory consistent with its needs.

TABLE VI-2.1: Spare Parts List

PARTS	Single Module Installations	Multiple Module Installations
Fans	1	2
Motors	1	2
Nozzles	1	2
Float Valve	1	2
Basin Heater*	1	2
Temperature Control Thermocouple*	1	2

* If Applicable

Most tower parts are in stock at the Tower Tech facility ready for immediate shipment. Contact your Tower Tech Sales Representative at (405) 222-2876 for information on these items.

SECTION VIII

APPENDIX

1. GENERAL CONDITIONS OF SALE

Tower Tech, Inc. ("Tower Tech") shall provide Purchaser the material, equipment, labor and services described in the attached proposal subject to the following terms and conditions which are part of these General Conditions of Sale and shall be deemed to have been accepted by Purchaser when Purchaser issues a purchase order for any item in the proposal.

1. **PERMITS, LICENSES, APPROVALS.** Purchaser shall obtain at Purchaser's expense all permits and licenses and pay all fees and similar charges required by law or local practice in connection with unloading, erection, and operation of the equipment necessary or convenient to complete the project including erection of temporary or permanent structures. Purchaser shall procure from the proper authorities the approval of the plans and specifications. If Purchaser fails to obtain any necessary approval, Tower Tech may obtain the approval, and upon demand, the Purchaser shall reimburse Tower Tech all cost and expenses incurred by Tower Tech in connection therewith.
2. **AUXILLARY EQUIPMENT.** Purchaser shall furnish and install at its own expense:
 - a. Adequate site preparation, foundations and substructure.
 - b. The piping, valves, fittings, electrical wiring, utility hook-ups, equipment and installation of all items necessary for completion of the project but not specified in the proposal to be furnished by Tower Tech.
3. **TAXES.** All federal, state, or local sales, use or other excise taxes in connection with the transportation, sale erection or use of the equipment not expressly included within the contract price shall be paid by Purchaser. Purchaser shall compensate Tower Tech for increases in the rates, license fees, permit fees, or taxes imposed after the date of the proposal.
4. **DELAY.** Tower Tech shall not be liable for loss or damage resulting from delay or failure in the performance of its obligations to the extent that such performance is prevented or delayed due to acts of God or the public enemy, strikes, lockouts, other concerted action of workmen, fire, explosions, perils of sea, floods, drought, epidemic or other casualty, war whether or not affecting the countries of the contracted parties, blockades, embargoes, insurrections, riots, sabotage, shortage or failure of supply of labor, fuel, power, raw materials for manufactured products, interruption or delay in transportation, accident, compliance with any regulations, order or request issued by any governmental authority or office or agency thereof of any cause, whether or not of the kind herein enumerated, for which Tower Tech is not solely responsible. Upon the occurrence of any such event preventing Tower Tech from performing its then outstanding contracts, Tower Tech shall be entitled to perform such contracts or portions thereof as it may select, in its sole discretion, and shall incur no liability to Purchaser by reason thereof. If shipment of equipment is delayed by Purchaser or by Purchaser's failure to provide adequate site or adjacent storage area after

commencement of fabrication of the material, the material contract price shall be due and payable when fabrication is completed and ready for shipment.

5. **FREIGHT**. Delivery of products by Tower Tech shall be F.O.B. Tower Tech, Inc., Chickasha, Oklahoma. Date of delivery shall be the date the product is delivered to the carrier for transportation to the Purchaser's site.
6. **RISK OF LOSS**. After delivery to the carrier for transportation to the Purchaser's site, Purchaser shall be responsible for loss or damage to materials, goods, merchandise, tools and equipment due to any cause, including but not limited to loss or damage resulting from casualty.
7. **TITLE**. Title to materials, goods, merchandise, tools, and equipment shall pass to the Purchaser on the date of completion. "Date of completion" shall mean 12:00 o'clock noon of the date after completion of erection specified by Tower Tech by notice in writing to Purchaser delivered not less than twenty-four (24) hours in advance to Purchaser. The statements concerning title shall not affect assumption of the risk of loss by Purchaser as provided in this contract.
8. **CANCELLATION**. If Purchaser cancels this contract, it is agreed:
 - a. Purchaser shall pay Tower Tech fifteen percent (15%) of the contract price.
 - b. After delivery to the carrier for transportation to Purchaser's site, the full contract price is due.
9. **MATERIAL/WORKMANSHIP WARRANTY OF MATERIALS AND EQUIPMENT**. Tower Tech warrants for a period of one (1) year that it will repair or replace defective material or workmanship in the cooling tower and its components for material and equipment manufactured by Tower Tech. Items not purchased from Tower Tech are not covered under the warranty. In addition to the one-year warranty, Tower Tech warrants for a period of four (4) additional years that it will repair or replace defective material or workmanship in the cooling tower exterior shell, excluding pigment and cosmetic deterioration; the pre-engineered fiberglass substructure if purchased from Tower Tech, excluding pigment and cosmetic deterioration; the water distribution system comprising PVC piping and rotary spray nozzles, fan assembly; and the water collection system. This material and workmanship warranty is subject to the following conditions:
 - a. Receipt from Purchaser of prompt written notice containing a full description of defects within the warranty;
 - b. Purchaser shall not without Tower Tech's written approval have attempted to correct the defect;
 - c. Purchaser shall have operated and maintained the equipment strictly in accordance with industry standards for evaporative cooling towers;
 - d. The defect has been caused solely by faulty materials or workmanship for which Tower Tech is responsible, and is not due to such things as erosion, corrosion or other physical deterioration caused by exposure to the elements,

- normal wear and tear or from abuse, neglect or operation of the equipment in conflict with prevailing standards of the cooling tower industry;
- e. All liability of Tower Tech shall be limited, at Tower Tech's sole option, to the repair and replacement of defective parts;
 - f. If equipment has been installed by parties other than Tower Tech, the equipment must be installed according to manufacturer's specifications;
 - g. All warranties begin to run on the date of delivery.
10. **MATERIALS AND EQUIPMENT MANUFACTURED BY OTHER PARTIES.** Benefits to Tower Tech, if any, with respect to materials and equipment manufactured by other parties but furnished to Tower Tech, are hereby assigned to Purchaser.
11. **LIMITATION OF LIABILITY.** Tower Tech's liability under this proposal and paragraphs 9 and 10 are expressly limited as follows:
- a. The warranties set for in paragraphs 9 and 10 are Purchaser's exclusive remedies against Tower Tech, Inc., and are in lieu of any other warranties or guarantees, express or implied, including the warranties of merchantability and fitness for a particular purpose.
 - b. Tower Tech shall not be liable to the Purchaser for any consequential or indirect damages including, but not limited to: loss of profits or revenue, loss of use of equipment, costs of replacement tower, additional expenses incurred in the use of equipment or facilities, or claims of customers of the Purchaser. The disclaimer shall apply to consequential damages based upon any cause of action asserted against Tower Tech including claims arising out of breach of warranty, expressed or implied, guarantee, product liability, negligence, personal injury or any other claim pertaining to the performance or non-performance of this contract by Tower Tech;
 - c. Adequate engineering and quality control must be performed by Purchaser to assure that the product purchased is suitable for its application. Tower Tech shall not be responsible for handling or modification by Purchaser, or end use of Purchaser's product.
 - d. No statement, remark, agreement, representation, promise or understanding, oral or written, made by Tower Tech, or its agent, representative, or employee, which is not contained herein will be recognized or enforceable or binding upon Tower Tech.
12. **ENTIRE AGREEMENT.** The proposal and general condition of sale are the entire agreement between Tower Tech and Purchaser with respect to the subject matter hereof. This agreement may not be modified or amended except by a written instrument signed by a duly authorized representative of each party. If Purchaser's order form is used, it is expressly agreed that the terms and conditions set forth in this agreement shall prevail insofar as the same may in any way conflict with the terms and conditions set forth in Purchaser's order form, or other Purchaser documents. The issuance of such order by Purchaser shall be deemed to denote Purchaser's assent to the foregoing.

13. **STATUTE OF LIMITATION.** Any action for breach or this contract negligence or any other action or cause resulting from this contract, or work performed or material furnished hereunder(except as provided by express warranties) must be commenced within one (1) year after the cause of action accrues.
14. **GOVERNING LAW.** This agreement shall be governed by the laws of the State of Oklahoma.
15. **ARBITRATION.** All disputes and claims between the parties which may arise in connection with this contract shall be settled in good faith negotiations between the parties. If the parties are unable to resolve any disputes or claim between them by good faith negotiations, such a dispute or claim shall be resolved by arbitration through the American Arbitration Association to be held in Chickasha, Grady County, Oklahoma, USA..
16. **ATTORNEYS FEES.** If any party to this contract is required to bring any legal action or seek enforcement of the terms or provisions of the agreement, the party who prevails in such action shall be entitled to reimbursement for all expenses incurred in such action including reasonable attorney fees.
17. **WAIVER.** No waiver shall be deemed to be made by any party of any right under this contract unless the waiver is in writing signed by that party. Each waiver, if any, shall be a waiver only with respect to the specific instances involved. No waiver shall impair the rights of the waiving party or the obligations of the other party in any other respect at any other time.

12/01/96

2. GLOSSARY OF TERMS

Air Inlet - Opening in a cooling tower through which the intake air enters. This occurs between the panel legs near the ground of the concrete cooling tower.

Ambient Temperature - The external outdoor temperature in the vicinity of the tower.

Approach - Temperature difference between the cold water exiting the tower and the wet bulb temperature.

Cell - The smallest division of the tower that can function as an independent unit. It typically consists of one fan and set of mechanical equipment, the distribution system, the collection system, and accompanying walls. The Tower Tech Modular Concrete Cooling Tower is available in two cell sizes: 24 ft X 24 ft and 36 ft X 36 ft.

Cellular Fill - The packing media located between the collectors and drift eliminators. The fill media provides a surface to distribute and interface the air and water. Several flute sizes and thicknesses are available.

Cold Water Temperature - The temperature of the water entering the basin after it has been cooled in the tower. This is one of the principal factors used when sizing a tower.

Counterflow - The hot water and air mix while flowing in opposite directions; the water falling downward while the air is forced upward.

Distribution System - The parts of a cooling tower responsible for passing the hot water to the designated cooling areas. This includes headers, laterals, piping, nozzles, etc.

Drift - Water droplets entrained in the exhaust air stream that were not captured by the drift eliminators.

Drift Eliminators - An assembly of baffles and passages which remove water droplets entrained in the exhaust air stream. The drift eliminators are located at the top of the tower cells.

Fan Pitch - The angle that a fan blade makes with the plane of rotation, measured at a specified point on each blade.

Float valve - A valve that is mechanically actuated by a float and is used to control the flow of make-up water to the tower basin.

Forced draft - A type of cooling tower with the fan located on the air inlet side of the tower, forcing air up through the tower.

Hot Water Temperature - Temperature of the water entering the tower's distribution system.

Induced Draft - A type of cooling tower with the fans located on the exhaust side of the tower, inducing the air flow through the tower.

Make-up - Water added to the cooling tower system to replace water lost due to evaporation, drift, and blowdown.

Plume - Visible exhaust exiting the tower caused by water condensation in the saturated air stream.

Pump Head - Energy required to raise the water through a height differential and overcome losses due to friction, valves, fittings, nozzles, etc. It is typically measured in units of feet of liquid.

Range - The temperature difference between the hot water entering the tower and the cold water exiting the tower. This is one of the principal factors used in sizing a cooling tower.

Spray Nozzle - The device used in the distribution system to break up and disperse the water entering the tower. Tower Tech's patented Rotary Spray Nozzle sprays a square pattern for complete coverage of the fill media.

Wet Bulb - The temperature that air will drop to if it is allowed to adiabatically absorb moisture until it reaches saturation (100 % relative humidity).