

ENGINEERING AND MATERIALS STANDARD
FOR
WATER COOLING TOWERS

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1. SCOPE

This Standard specification covers the minimum requirements for the water cooling towers in two parts as follow:

- Part 1:** Engineering requirements with exception of civil and structural engineering matters.
Part 2: Material of different parts and relevant components.

Note:

This Standard shall be used in conjunction with BS 4485. In case of conflict this Standard shall govern.

2. REFERENCES

The following standards have been used to prepare this Standard. References are sometimes given exactly to some items of applicable standards.

BSI (BRITISH STANDARDS INSTITUTION)

BS 4235: Part 1	"Specification for Metric Keys and Keyways Parallel and Taper Keys"
BS 4485: Part 1	"Water Cooling Towers (Glossary of Terms)"
BS 4485: Part 3	"Water Cooling Towers (Code of Practice for Thermal and Functional Design)"
BS 4485: Part 4	"Water Cooling Towers (Structural Design of Cooling Towers)"
BS 5512	"Specification for Rolling Bearings-Dynamic Load Ratings and Rating Life: Part 1: (Calculation Methods)"

CTI (COOLING TOWER INSTITUTE)

CTI Bulletin WMS-112	"Pressure Preservation of Lumber for Industrial Water Cooling Towers"
CTI Bulletin NCL-109	"Nomenclature for Industrial Water Cooling Towers"
CTI Bulletin ATC-105 and Relevant Addendum	
CTI Bulletin STD-114 (86)	"The Design of Cooling Towers with Douglas FIR Lumbars"

AGMA (AMERICAN GEAR MANUFACTURERS)

"Gear Specifications"

NIOC (NATIONAL IRANIAN OIL COMPANY)

SP 2219-47-257	"Job Specification for Cooling Towers"
SP 2219-47-10	"Noise Level Requirements and Measurements"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-M-PM-230	"Special Purpose Centrifugal Fans"
IPS-M-PM-235	"General Purpose Centrifugal Fans"
IPS-E-SF-880	"Water Pollution Control"
IPS-E-SF-900	"Noise and Vibration Control"

IPS-M-EL-132	"Induction Motors"
IPS-E-PR-755	"Process Design of Fans and Blowers"
IPS-E-EL-110	"Electric Area Classification and Extent"

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)

NFP A 214

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIAL)

ASTM-B179

ASTM-A123

3. DEFINITIONS AND TERMINOLOGY

For the purpose of this Standard definitions and terminology given in BS 4485: Part 1 and CTI Bulletin NCL-109 shall be used.

4. SERVICE CONDITIONS

This Standard is prepared to be used for the technical requirements of the water cooling towers in the refineries and petrochemical plants with their specific service conditions.

5. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

PART 1

ENGINEERING REQUIREMENTS

6. DESIGN REQUIREMENTS

The matters described in this Part of standard are the minimum requirements which shall be considered in the design of water cooling towers.

6.1 Parameters Involved in the Design of the Cooling Towers

The parameters involved in the design of the water cooling towers are described in this Standard and those included in the Appendices "A" and "B" of this Standard. Appendix "A" shall be filled up by purchaser and provided to the Vendor and Appendix "B" shall be filled up by Vendor and submitted to purchaser along with other documents.

6.2 General Thermal Design

6.2.1 Thermal design principles

Clause 3 of standard BS 4485: Part 3: 1988 shall be considered.

6.2.2 Type of packings

All requirements having effect on the selected type of packings shall be reviewed by Vendor considering the followings and a report shall be submitted to the purchaser:

a) Individual packing assemblies shall be removable and designed to prevent movement or sagging. If splash type packings are selected, provisions shall be made by Vendor for horizontal installation.

b) Optimum design requirements

The type of packings shall be selected to provide the optimum design requirements. These optimum design requirements and the parameters to determine them shall be specified by Vendor.

c) Analysis and temperature of water

The Vendor shall study the design requirements of cooling tower and propose the required procedures for water filtration or treatment, make up water required and selected type of packings based on economical and technical evaluation of different systems to justify the selected type of packings.

d) Type of cooling tower and its duty

If the cooling tower duty is to cool a certain amount of warm water in an open circuit and discharge it to river, lake, sea, or similar type of disposals, it may be possible to use splash type packings with adequate water filtration to eliminate the necessity of performing frequent washing of packings. In this case enough space shall be provided between packings elements.

e) Air pressure drop

Air pressure drop through the packings shall be optimized to decrease the fans power in mechanical drought cooling towers and tower height in natural drought cooling towers.

f) Cooling tower dimensions

The Vendor shall review the available space for the cooling tower to select proper type of packings, because it may be necessary to use film type packings to fit the cooling tower in the available space. In this case proper filtration and treatment of circulating water and optimum quantity of make up water shall be used.

g) Minimum water loading

The Vendor shall provide technical justification in the report that in the selected type of packings no channeling will happen when the cooling tower is operating at all flow rates from minimum to maximum.

6.2.3 Drift eliminators

The type, design and location of drift eliminators shall be selected in a way as to provide the following requirements:

- a)** Optimum efficiency to separate water particles and moisture carried by air to limit the maximum allowable drift loss to 0.01% of the design water flow rate for fresh water services and 0.008% for salty and brackish water services, unless otherwise specified.
- b)** They shall be easily removable and accessible to permit maintenance and repair. In counterflow type cooling towers, drift eliminators design shall allow ready access to distribution system headers, laterals and nozzles and in crossflow type towers, the drift eliminator's design, shall include removable sections to allow access to the tower packings area.

6.2.4 Recirculation

A detailed report shall be prepared by the Vendor and submitted to the purchaser considering the following points to optimize the quantity of recirculation air:

- a)** Clauses 7.3, 5.2.3 and 5.2.4 of BS 4485: Part 3: 1988.
- b)** Appendix "C" of this Standard.

6.3 Water Quality Requirements

The following elements shall be considered by the Vendor:

- a)** Clauses 8.4, 8.6 and 8.7 of BS:4485: Part 3: 1988.
- b)** Other relevant requirements in this Standard.

A report shall be prepared by the Vendor and submitted to the purchaser considering the above mentioned elements. In this report optimum selected procedures and designs to have the best cooling tower operation from economical and technical points of view shall be stated.

6.4 Water Losses

Water losses from the cooling tower consist of:

- a)** Evaporation losses(1);
- b)** purge losses (blow down);
- c)** blow out losses;
- d)** drift losses(2).

A report shall be prepared by the Vendor considering Clause 8.2 of BS 4485: Part 3: 1988 and the following points and submitted to the purchaser:

This report shall include detailed calculation to determine above mentioned losses and provisions foreseen in the design of cooling tower to optimize and compensate them. Economical and technical evaluation shall also be included in this report for different amounts of the concentration factors, water losses and water treatment and filtration procedures and the selected ones shall be specified too. It is notable that price evaluation of all effective factors such as make-up water, equipment, etc. shall be done in this report.

Notes:

- 1) The evaporation losses shall not exceed 2.7% of the total circulating water flow rate.**
- 2) Free water carry over (drift losses) shall not exceed 0.01% of the total circulating water flow rate for fresh water and 0.008% of the total circulating water flow rate for salty and brackish water.**

6.5 Water Distribution Systems

The following factors shall be considered:

- a)** They shall be designed in a way to have an even water distribution over packings.
- b)** All pipings and relevant equipment shall be designed for 120% capacity.
- c)** For cooling towers with film type packings, spray nozzles shall be used for water distribution over packings.
- d)** For cooling towers with splash type packings, proper nozzles or splash plates shall be used.
- e)** Spray nozzles shall be self draining, non-clogging type.
- f)** Inlet water piping furnished by Vendor shall terminate with flanged connections. Flange rating and facing and the orientation and elevation of the connections will be specified where necessary to match purchaser's mating piping connection.
- g) For counterflow cooling towers:**
 - A separate central header shall be provided on each cell complete with laterals, fittings and spray nozzles.
 - Headers and laterals shall be provided with cleaning access or flush-out facilities depending on the purchaser's approval.
 - Distribution systems shall incorporate means of accommodating pressure surges.
- h) For crossflow cooling towers**
 - Each water distribution basin shall be fed through a flow control valve. Valves shall be mounted external to the distribution header.
 - Water distribution basins shall be covered to exclude sunlight. Covers shall be removable to permit access and periodic inspection.

i) Partitions

It is preferable that a tower be easily divisible into maintenance areas. in the case of multi-cell towers, each cell water system shall be separately controlled.

In natural draught towers, maintenance may be based on one-half of a tower being taken out of commission by permanent dividing walls and valving of the distribution system. The cold water basin should be similarly divided.

In mechanical induced draught cooling towers the followings shall be considered:

- Towers consisting of two or more cells shall be provided with transverse partition walls. The walls shall extend from the normal water level to the fan deck to permit each cell to be taken out of service without affecting the operation and capacity of other cells.
- Individual cells serving with two or more fans shall be provided with partition walls. The walls shall be centered between fans, extending from the fan deck to the top of the packing, to minimize the recirculation of air and by passing of the packing when one or more fans are not operating.

In mechanical draught counterflow cooling towers, individual cells serviced by one fan and having more than one louver face shall be provided with a partition wall. The partition shall extend from the normal water level in the basin to the elevation of the top of the air inlet louver and shall be so located as to prevent air from blowing from one louver face through the other louver face.

6.6 Winter Operation Design Requirements

If considering the following factors necessitates provisions to face with freezing and icing hazards, one or a combination of the methods described in the following Clauses of 6.6.1 to 6.6.7 shall be employed in the design of cooling tower:

- a) weather conditions prevailing at site;
- b) design requirements of the cooling tower such as type, counterflow or crossflow, range, approach and air and water flow rates;
- c) water distribution system;
- d) water basin design and its location;
- e) stagnant points in any part of the cooling tower;
- f) other factors.

A complete and comprehensive report about the required provision shall be prepared by the Vendor and submitted to the purchaser. In this report all above mentioned factors shall be discussed and provisions provided to face with freezing and icing hazard shall be stated.

6.6.1 Two speed fans and fans stopping

In order to decrease the air flow rate through the forced draught or fan assisted natural draught cooling towers, the following two steps according to the degree of freezing hazard may be implemented:

- Step 1:** Reducing the fans speed of two speed type.
- Step 2:** Stopping proper number of fans.

6.6.2 Fans reversing and speed control

In the induced type cooling towers fans reversing will cause warm air passing through the inlet air area and eliminating ice or freezing hazard. Using fans with variable multispeed motors in the mechanical draught type cooling towers, the air flow rate can be decreased by reducing the fan speed as required to eliminate the icing and freezing hazard.

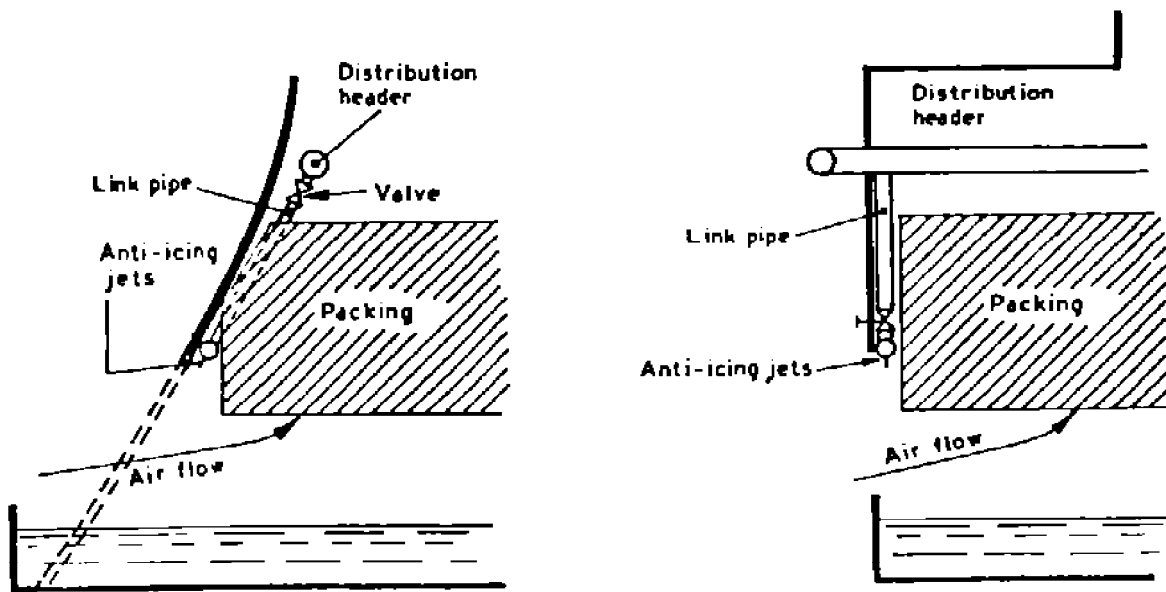
6.6.3 Variable pitch

Using variable pitch fans may be a solution to face with icing and freezing hazard.

6.6.4 Preheating the inlet air to the packings using hot water bypass

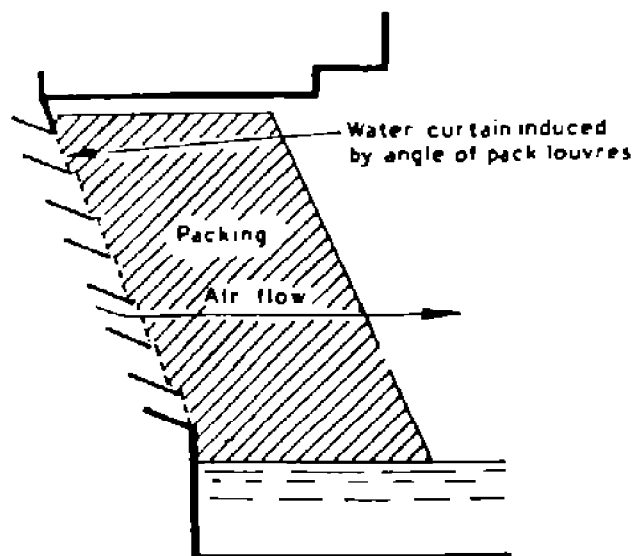
In order to warm the inlet air to the cooling tower to eliminate the freezing hazard a proper portion of inlet warm water may be bypassed into the air inlet path. Typical arrangement of this method is shown in Fig. 1. In this case water jets shall be used and using water sprays are not allowed.

Generally by pass shall operate under a pressure head of not less than 2 m (having allowed for friction losses), the nozzles shall be of a diameter not less than 12 mm, and the total bypass flow shall be about 25% of the circulating water-flow rate. The effect of anti-icing piping shall be considered in the design of the cooling tower.



a) Natural draught mixed flow

b) Mechanical draught mixed flow



c) Mechanical draught crossflow showing induced water curtain

Fig. 1

6.6.5 Adjustable inlet air louvers

For reducing the air flow through the cooling tower, adjustable inlet air louvers may be used. This system shall be operated automatically.

6.6.6 Reducing the number of packing cells in operation

In this method the following points shall be considered:

- a) Complete isolation of proper numbers of packings cells.
- b) Avoid any static water in any part.

6.6.7 Prevention of basin water from freezing

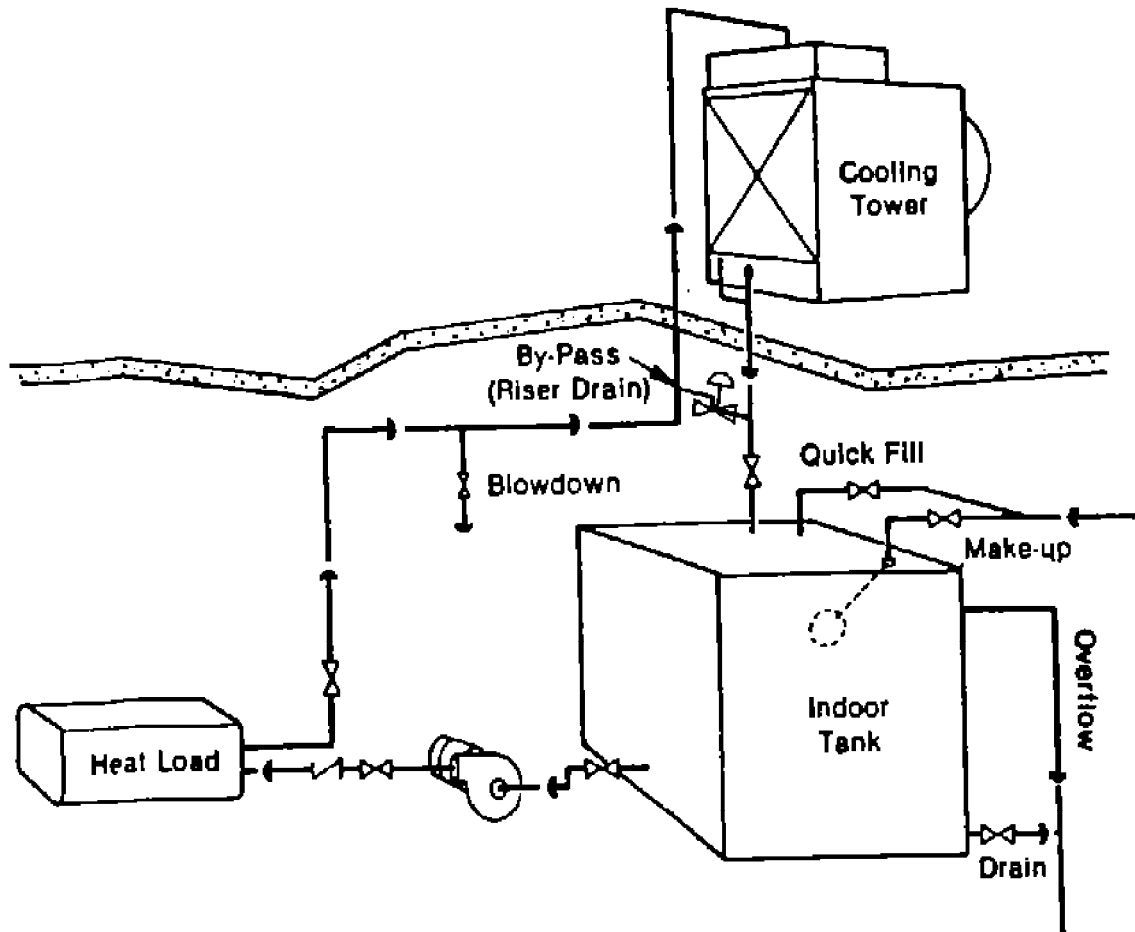
To prevent the basin water from freezing, during shut down of the cooling tower, one of the methods described in Clauses 6.6.7.1 to 6.6.7.4 shall be used depending on the design requirements, limitations imposed by available space and economical reasons:

6.6.7.1 Basin draining

Draining the basin water to a reservoir or to the drainage system of the plant.

6.6.7.2 Indoor tank method

A typical arrangement of this system which is also called dry basin operation is shown in Fig. 2. In this System there shall be a continuous flow of water from basin to an indoor installed tank at lower level. When the cooling tower stops, the by passline shown in the Fig. 2 allows quick drainage of the supply line to the cooling tower. In this bypass line an automatically opened control valve shall be provided to be opened when the cooling tower stops operation.



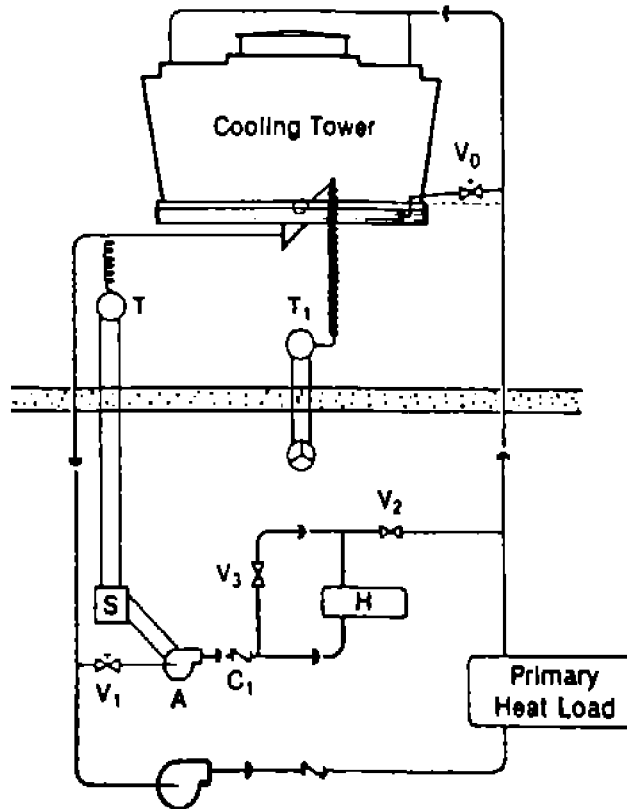
DRY BASIN OPERATION
Fig. 2

6.6.7.3 Electric immersion heater or steam heating methods

Electric or steam heating energy may be used to warm up the basin water.

6.6.7.4 By pass circulation method

This method prevents both the water in the basin and exposed pipes from freezing which shall have a typical arrangement as shown in Fig. 3 the flow of water in the by pass circulation circuit shall be 5% of the total water flow rate in the main circulation system.



BY PASS CIRCULATION SYSTEM
Fig. 3

Notes:

The descriptions of the components shown in Fig. 3 are as follow:

- A = By pass circulation pump
- S = Magnetic starter
- H = A small instantaneous water heater
- V₃ = Glob valve
- V₁ = Gate valve
- C₁ = Check valve
- T = Immersion thermostat
- T₁ = Thermostat and heating cable to protect the make up line
- V₀ = Gate valve
- V₂ = Globe valve

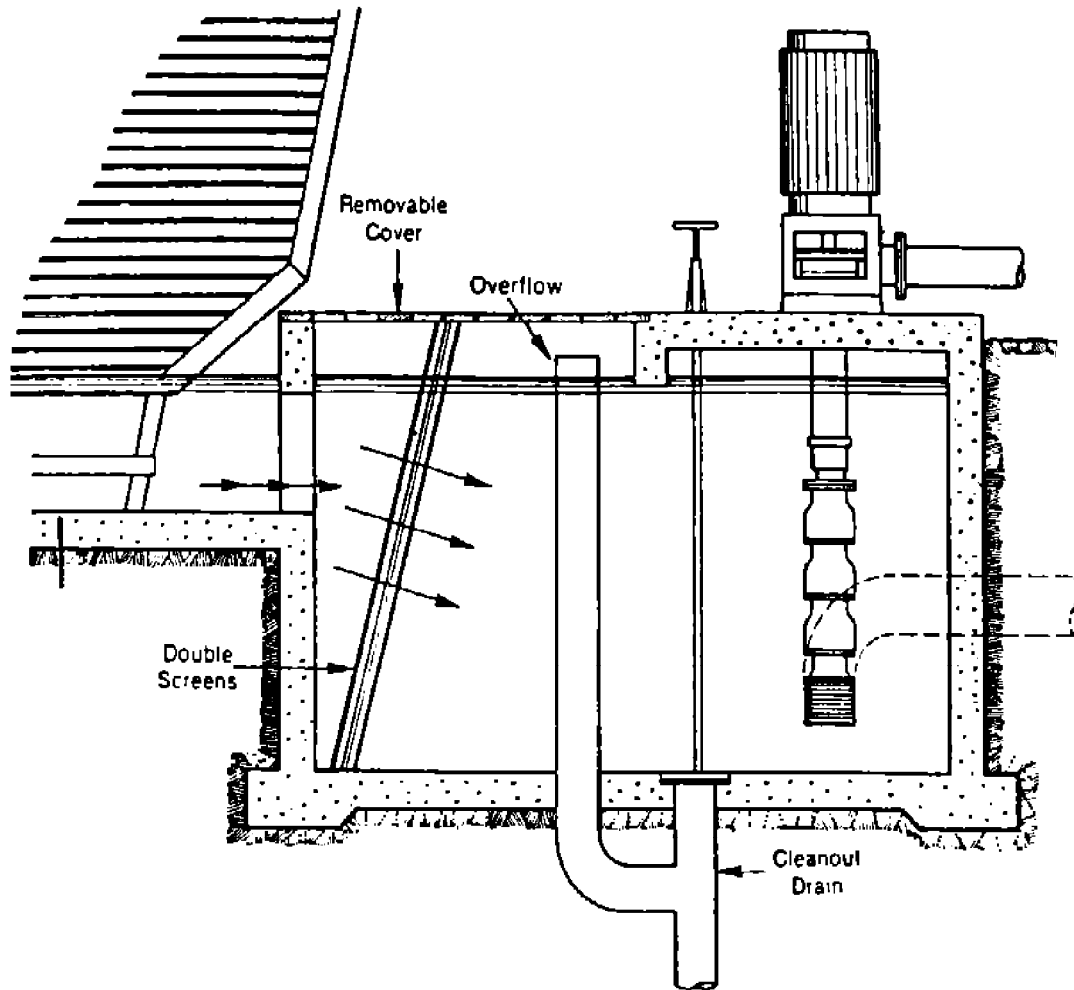
6.7 Water Basin Design

The following factors shall be considered in the design of water basin:

- a) It shall be designed to be located under packings area.
- b) Collecting points of foreign materials shall be provided in the floor of the cooling tower and if it is possible, large capacity clean out drains similar to what is shown in Fig. 4 shall be provided.

The basin floor shall be properly sloped towards the collecting points of foreign materials, drain points and the clean out drains (if provided), to permit removing sediments and foreign materials. If proper drainage channel or

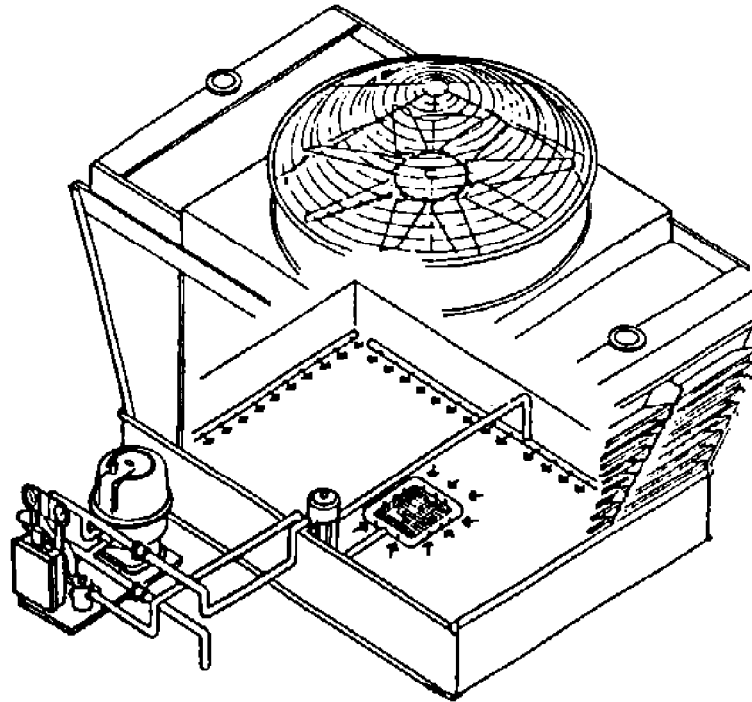
reservoir for gravity drainage of basin could not be provided, clean out drains similar to what is shown in Fig. 4 with a drainage pump shall be provided to discharge the drained water to safe drainage or disposal system.



A TYPICAL DESIGN OF CLEAN OUT DRAIN
Fig. 4

- c)** Over flow facilities shall be provided in the design of the basin and indoor tank.
- d)** Basin and indoor tank shall be provided with control valve and level controller connected to the make up water system to adjust the water level in them.
- e)** The circulating pump, basin location and indoor tank location shall be prepared in a way that available net positive suction head (NPSH) for pump is more than required NPSH at whole operating range of the cooling tower.
- f)** Basin shall be divided, if practicable, into separate divisions to enable to put each one out of service without interrupting the operation of remaining parts. Each basin division shall be sloped towards collecting points of foreign materials, from where it shall also be possible to drain the relevant basin section.
- g)** The capacity of basin or indoor tank (depending on the situation) shall be determined considering the following points:
 - Item 8.3.2 of BS 4485: Part 3: 1988.
 - The effective water capacity of basin or indoor tank shall be enough for a minimum of 10 minutes based on the design water flow rate and normal operating water level.

h) In special cases where there is a high content of suspended solids in the water, side stream filtration as shown typically in Fig. 5 may be provided to filter very small particles subject to purchaser's requirement. It shall be sometimes necessary to provide it along with other proper filtration and treatment systems.



A TYPICAL SIDE STREAM FILTRATION SYSTEM
Fig. 5

i) For concrete basins, the water velocity inside the basin at any point shall not be less than 0.3 m/sec at full load condition.

6.8 Siting, Orientation, Spacing and Environmental Considerations

6.8.1 Siting, orientation and spacing

6.8.1.1 Tower level

The cooling tower shall be located either above or below the heat source considering the following points:

- a)** The "NPSH" available for pump shall be more than required "NPSH".
- b)** It shall be possible to face with the drain back from the system (when the circulation system stops), with a proper design without any flooding and loss of water.

6.8.1.2 Air restrictions

The cooling tower shall be located in a position to provide a minimum of twice the area of the tower inlet opening. Air flow restricting objects may be barriers, equipment, buildings, enclosures and any other object.

6.8.1.3 Recirculation and orientation of the cooling tower

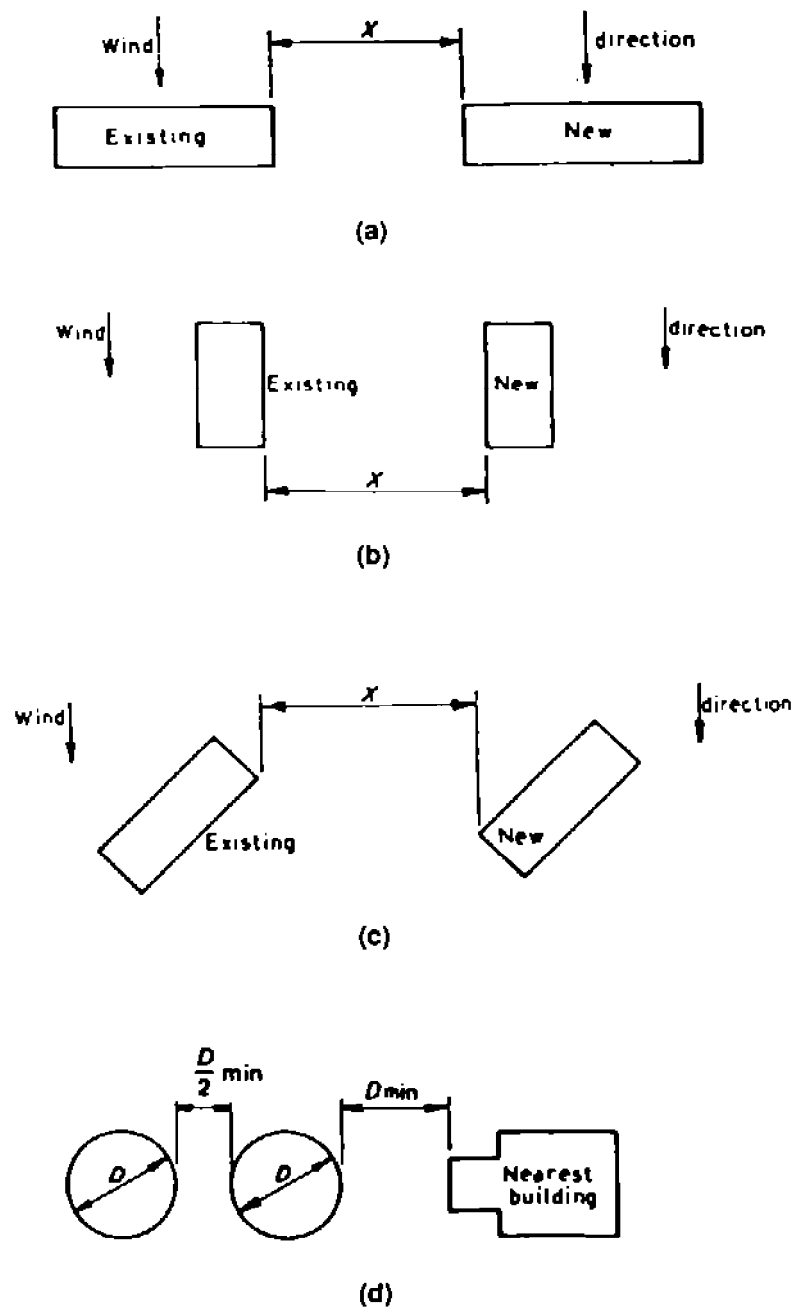
Clause 6.2.4 of this Standard shall be considered.

6.8.1.4 Interference

The type, shape and location of the cooling tower shall be so selected and designed, so that the interference effect will be optimized.

6.8.1.5 Spacing

Clause 5.3 of BS 4485: Part 3 and Figs. 6 to 9 shall be considered.



SPACING OF COOLING TOWERS
Fig. 6

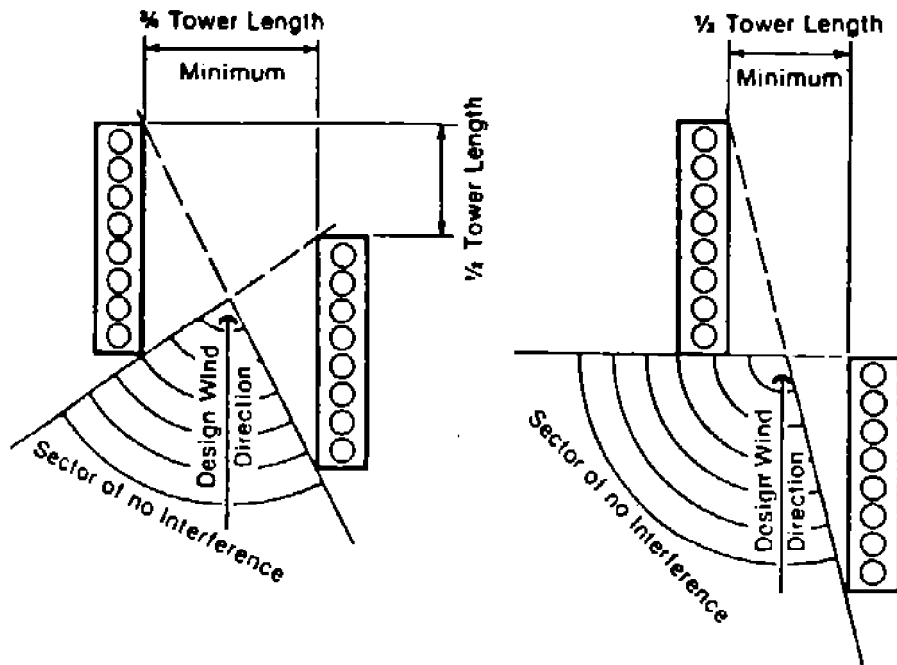


Fig. 7

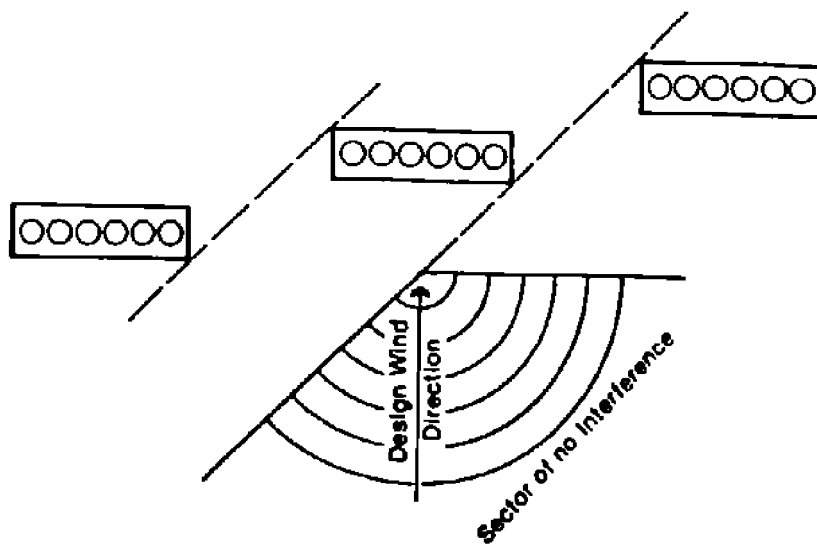
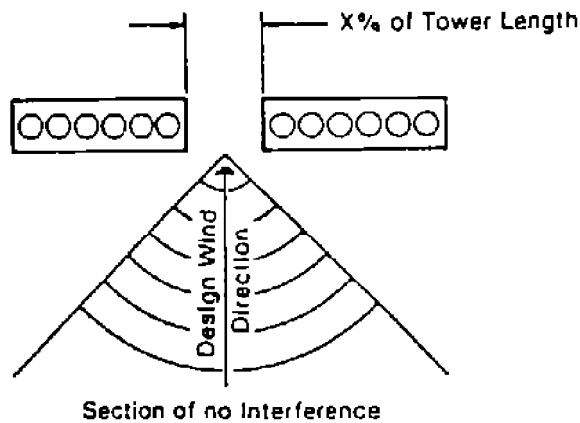


Fig. 8



The % of tower length separation is primarily a function of the tower's physical characteristics.

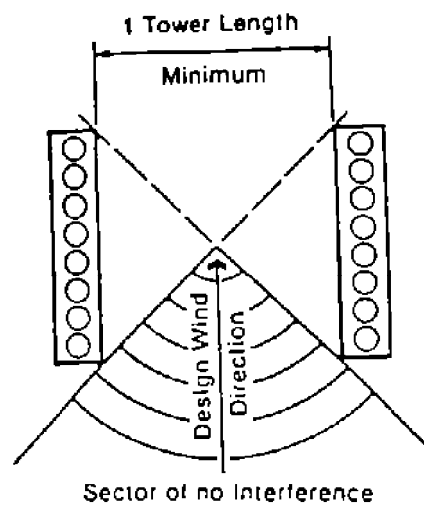


Fig. 9

6.8.2 Environmental considerations

The effects of drift, blow out, fogging and noise are some of the contributing factors that shall be considered as follow, when siting cooling tower installation:

6.8.2.1 Reducing the drift effects

In order to reduce the drift effects, the following points shall be considered:

- a) The cooling tower shall be located in a place that considering the direction and speed of prevailing wind, the drift will not be spread over nearby roads, buildings, equipment, residential areas and etc.
- b) Effective drift eliminators shall be used to optimize the drift losses not to create excessive pressure drop in the air flow path, which causes either using fans with higher capacities in mechanical draught cooling towers or a higher height for natural draught cooling towers.
- c) The eliminators shall be installed correctly not to have any gap between themselves and structure to prevent escaping the water droplets.
- d) Spacing between packings and eliminators shall be increased sufficiently to have enough time for the droplets to fall before they reach to the drift eliminators.

6.8.2.2 Reducing the blow out nuisance

Where the blow out creates a nuisance, it shall be reduced by one or a combination of the following means:

- a) Diagonal partitions or central division shall be situated so that the prevailing wind is prevented from blowing across the tower basin.
- b) Inclined louvers boards shall be positioned around the air opening at the base of the tower, sections of which shall be removable to permit access.

6.8.2.3 Reducing the fogging and plume nuisance

A combination of the following actions shall be taken:

- a) Considering the direction and speed of prevailing wind, the cooling tower shall be located in a place to have the optimum possible hazard.
- b) Heating the moist air before leaving the cooling tower as shown in Fig. 10 to reduce fogging.
- c) Discharging the fan stacks warm vapors at higher levels.

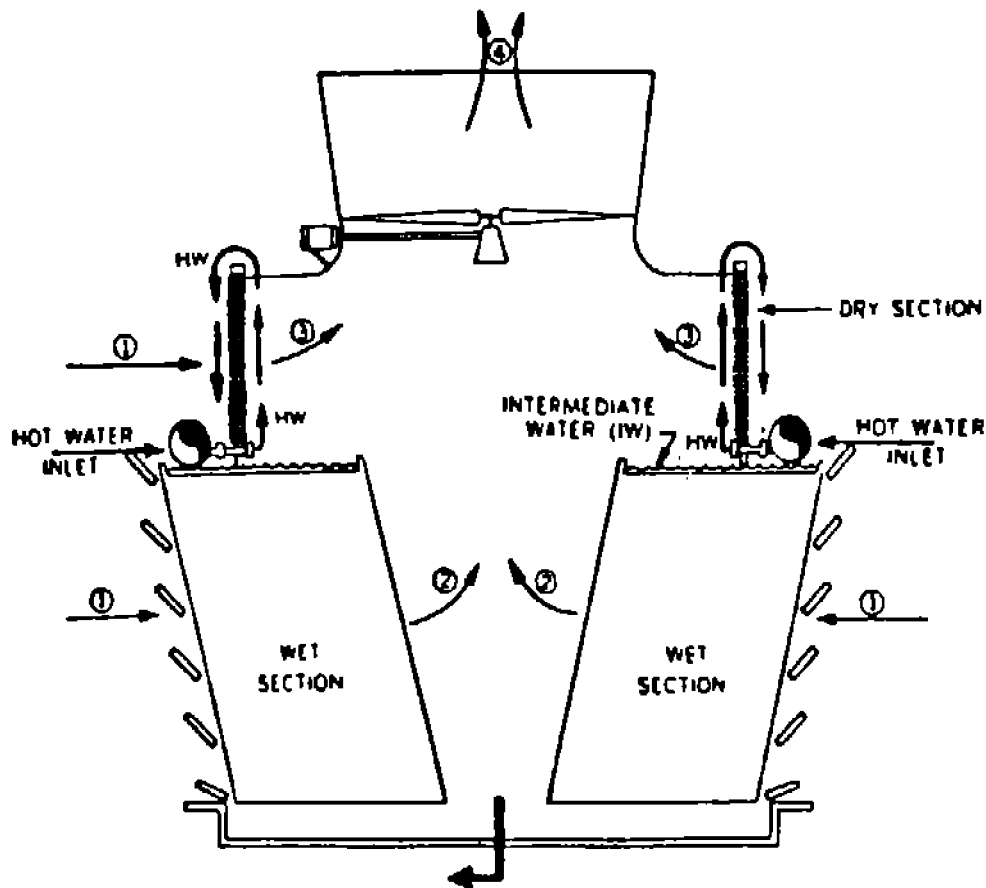


Fig. 10

6.8.2.4 Blow down and draining

Standard IPS-E-SF-880 shall be considered.

6.8.2.5 Noise level

IPS. Standard E-SF-900 and the following points shall be considered:

- a) Clause 5.4.7.7 of BS 4485: Part 3.
- b) Enclosing the cooling tower by sound attenuating barriers shall be used, subject to purchaser's approval, in places where high limitation on sound level exists.

6.9 Mechanical and Electrical Equipment

6.9.1 Fans

6.9.1.1 Fan laws and formulas

Standard IPS-E-PR-755 shall be applied.

6.9.1.2 Fans types

For selection of the fans type, their number and major design requirements, the following factors shall be considered:

- a) Cooling tower type and arrangement of components.
- b) Design requirements of the cooling tower.
- c) Air flow rate through the cooling tower.
- d) Pressure drop of air path in the cooling tower.
- e) Noise level restrictions.
- f) Input power to the fans.
- g) Location of installation.
- h) Available area for the cooling tower.
- i) And the requirements described in Clauses 6.9.1.2.1 to 6.9.1.5.

6.9.1.2.1 Axial flow (propeller) fans

This type of fan shall be used in low static pressure drop cooling towers where high quantity of air flow rate is required. The following aspects shall be considered in the design and fabrication of this type of fans:

- a) They shall be equipped with manually adjustable pitch blades at least for the range of 0° to 22° enabling the fan to be applied over a wide range of operating horsepower.
- b) Fans shall be designed to operate at tip speed not more than 61 m/sec.
- c) The fans shall be in dynamic and static balance with a minimum of noise.
- d) They shall be designed to have uniform air velocities across the effective area of fan.
- e) They shall be mainly used in the induced type mechanical draught and fan assisted natural draught cooling towers. In these cases the fan shall be of a material, or have a protective finish that will resist corrosive effects of warm and humid operating conditions. Protective finishes shall be capable of withstanding the erosive effect of impacting water droplets.

6.9.1.2.2 Centrifugal flow fans

These type of fans shall be mainly used for indoor installations of forced draught cooling towers. The fans of the forced draught type cooling towers may be affected by dust and debris (depending on the ambient air conditions), so preventive provisions shall be provided and more over they shall be mounted so that any water entering the fan casing drains back into the cold water basin.

6.9.1.3 Natural frequency of fan

Fundamental natural frequency of fan blades shall not coincide with any source of vibratory excitation (any shaft speed) in the range from 10% below minimum operating speed to 10% above maximum operating speed.

6.9.1.4 Applicable standards

The two following standards shall be considered wherever applicable:

IPS-M-PM-230	"Special Purpose Centrifugal Fans"
IPS-M-PM-235	"General Purpose Centrifugal Fans"

6.9.1.5 Safety provisions

Protection guards shall be provided, wherever applicable, for fans, driver shafts and couplings.

6.9.2 Gearbox

Gearboxes shall meet the following requirements:

- a) It shall be double reduction, spiral bevel right angle type, with AGMA service factor of not less than 2.0 based upon driver horsepower.
- b) It shall be sealed to prevent moisture leakage at the shafts.
- c) Thermal rating of the gearbox shall be ample for operation without oil cooling.
- d) Connection of the gearbox for oil filling and oil level observation shall be extended to the outside of fan stack (cylinder).
- e) An oil level indicator shall be provided with a cut off switch on the oil circuit to shut off the fan motor at low oil level.
- f) The output shaft bearings shall have an L 10 life of 100,000 h. as defined in BS 5512: Part 1. As this produces reversing radial loads on the bearings, special consideration shall be given to the relationship between bearing clearances, fan bearing span and diameter.
- g) The elevated temperature of the surrounding air during normal operation shall be taken into account and, when located in a very cold climate, consideration shall be given to the problems of a cold start.
- h) Double oil seals are a preferred feature to minimize the risk of oil leakage or ingress of moisture. Gearboxes mounted in the induced draught-position, i.e. in the areas of near 100% humidity, shall be provided with a remote vent carried to the outside of the fan stack to minimize the risk of condensation from breathing moisture-laden air. Lubrication, grease pipes and oil-level indicators shall be taken to the outside of the fan to facilitate servicing.

6.9.3 Drive shafts and couplings

The following aspects shall be considered in design of drive shafts:

- a) Shafts shall be tubular with non lubricated Thomas flexible coupling Type I or equal for induced type cooling towers.
- b) Drive shafts shall be properly balanced.
- c) Drive shafts shall be capable of being rebalanced (if necessary) and accepting some degree of misalignment.
- d) Hollow rotating components shall be sealed to prevent water ingress or be effectively drained to prevent accumulated water impairing the balance.

6.9.4 Supports for mechanical equipment and drive motors

Consideration shall be given to the following factors in the design of supports:

- a) The supports shall be designed to minimize possible movement between the elements of the fan driver assembly, shaft and gearbox.
- b) Possible corrosive conditions.
- c) The vibratory loads from the fan unit.
- d) The excess force arising from possible damage to any part of complete fan and drive assembly.
- e) Additional requirements mentioned in BS 4485: Part 4.

6.9.5 Vibration cut out switch

One vibration cut out switch and alarm shall be provided for each fan with the following requirements:

- a) The cut out switch shall be provided outside the fan ring.
- b) In case of excessive vibration, the cut out switch shall shut down the fan automatically and permit restarting only when the problem is corrected and manually reset. The vibration switch shall be suitable for resetting the switch without disassembly.
- c) Provisions shall be made for adjusting the vibration switch so that it may be set above the vibration level of normal operation and/or will not trip out during fan start up.
- d) The vendor shall provide one alarm per fan to be activated when cut out switch trips the relevant fan.
- e) Vibration cut out switches shall be preferably ball type.
- f) Vibration cut out switches shall be tagged with identifying tag numbers.
- g) Vibration cut out switches shall be weather proof.

6.9.6 Keys and keyways

Keys and keyways shall be according to BS 4235: Part 1.

6.9.7 Valves

The valves mentioned in Clauses 6.9.7.1 to 6.9.7.3 shall be provided as a minimum:

6.9.7.1 Stop valves

Stop valves shall be provided considering the following requirements:

- a) Stop valves shall be provided in accessible positions.
- b) In cooling towers with multiple risers, separate stop valve shall be provided on each riser to regulate the flow in individual risers and/or stop flow in particular riser during partial maintenance of the cooling tower parts.
- c) These valves shall be normally of gate or butterfly type depending on the purchaser's requirement.
- d) Stop valves shall be provided for both crossflow and counterflow type cooling towers in single riser or multiple risers systems.

6.9.7.2 Flow control valves

Flow control valves shall be provided considering the followings:

- a) They shall be in accessible positions.
- b) They shall be installed in crossflow type cooling towers to equalize flow between distribution basins of a tower cell as well as between cells of multi-cell cooling towers.
- c) It shall be possible to use these valves to shut off flow to selected distribution basins for interim cleaning and maintenance purposes when other parts of the cooling tower are in operation.

6.9.7.3 Make-Up valve

Make-up valve shall be provided in the make-up water supply line to replenish the normal water losses from the system, automatically.

6.9.8 Fan motor

Fan motor shall be designed per following requirements:

- a) Motor shall be designed and selected for installation in hazardous area Class 1, Div. 2 as specified in IPS-E-EL-110.
- b) Fan motor shall not be placed in the air stream but shall be mounted in a location easily accessible for maintenance.

Fan stop push buttons to be located at ground level and start-stop push buttons to be located at fan level will be furnished by purchaser.

- c) Fan and motor shall be designed for continuous operation.
- d) Fan motor shall be in accordance with IPS-M-EL-132 "Induction Motors".

The motor shall be explosion/flame proof with two or variable speeds operation depending on the design requirements.

Motor horsepower shall be sufficient to meet the fan requirements at maximum required pitch angle and design speed.

- e) Motor shall have ratings, including service factors for fan and gear, at least equal to the following percentage of the rated brake kW of fan including gear loss:

Motor Nameplate Ratings	Percent of Rated Brake kW
19 kW & Less	130
22.5-56 kW	120
75 kW & over	115

However, the rated brake horsepower shall not exceed the motor nameplate rating. Where it appears that this will lead to unnecessary oversizing of the driver, an alternate quotation may be submitted for purchaser's consideration.

6.10 Safety Provisions

6.10.1 General

Safety provisions shall be provided in the design of the cooling tower and the relevant auxiliary equipment to minimize all hazards. The hazards generated by the cooling tower comprises of the followings and the others described in the relevant clauses of this Standard:

- a) Hazards generated by electrical, mechanical and instrumentation equipment.
- b) Hazards which may be encountered during personnel access and possibility of their trapping, in the extremely humid conditions, inside the cooling tower.
- c) Environmental hazards.
- d) Icing hazard.
- e) Fire hazard.

The procedures which shall be followed by the vendor to minimize the hazards are described in other relevant parts of this Standard and Clauses 6.10.2 to 6.10.5 of this part, but, however, vendor is responsible to provide provisions for any other hazard which may be encountered in the cooling towers during operation and/or shut down.

6.10.2 Electrical and instrumentation equipment

Emergency locked control switches shall be installed adjacent to all motors. All electrical plant and installation shall comply with the relevant electrical safety regulations and be suitable for the operating conditions. All electrical and instrumentation equipment shall be designed for installation in hazardous areas, Class 1, Div. 2 as specified in IPS-E-EL-110.

6.10.3 Access

The following facilities with suitable design conforming to the type and design requirement of the cooling towers shall be provided:

- a) Access to all parts of the cooling tower for maintenance, inspection and repair, consisting, but not limited, of ladders, doors, walkways, stairway, guard railing assembly, safety cages, jib crane or davits and cranes.
- b) Access doors shall be designed to be easily opened from the inside and shall be opened outwards. Access doors bolts, locks, etc., shall be such as to prevent accidental fastening.
- c) If escape ladders are provided they shall be extended to the floor.
- d) More than one access way shall be provided for high levels.

6.10.4 Guards on rotating equipment

Suitable and adequate guards shall be provided on rotating equipment for personnel safety.

6.10.5 Fire prevention

Properly designed, fire fighting, detection and alarm system shall be Provided by the Vendor for the cooling tower according to the design requirements of the cooling tower, Purchaser's requirements and materials selected for different parts. NFPA standard No. 214 may be followed in special cases. For the cooling towers containing wood in any part, wetting wood parts with enough water during cooling tower shut down shall be used. However selecting fire retardant materials will increase the reliability and safety of the cooling tower.

6.11 Special Requirements

6.11.1 Outlet water temperature lower limit

If the purchaser requires that the outlet water temperature shall not fall below a predetermined degree, then one of the following methods shall be provided by the vendor for cold times of the year:

- a) For locations where freezing condition does not exist, a bypass line shall be provided between inlet and outlet water line, as shown in Fig. 11, or the numbers of packing cells in operation and the air flow through the cooling tower shall be reduced.
- b) In locations with the possible freezing conditions, the cooling tower shall be equipped with multicell packings and/or multi-speed fans so that it will be possible to reduce the number of packing cells in operation and/or reducing the air flow through the cooling tower.

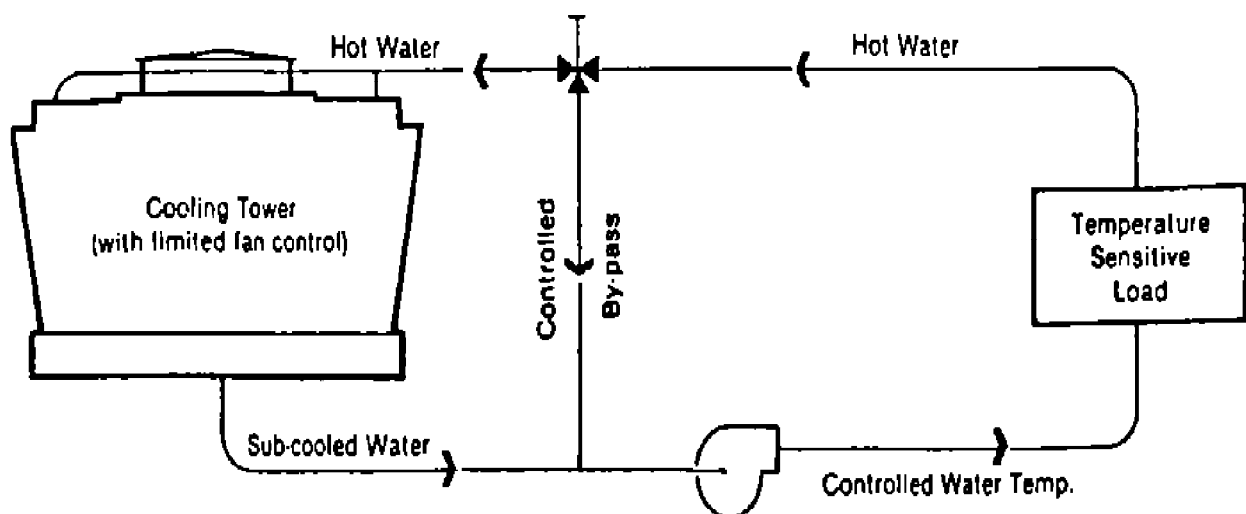


Fig. 11

6.11.2 Effect of the high temperature of the inlet warm water

If the highest expected temperature of the inlet warm water can harmfully affect the selected materials of some parts of the cooling tower, then the provision shown in Fig. 12 shall be provided by the Vendor.

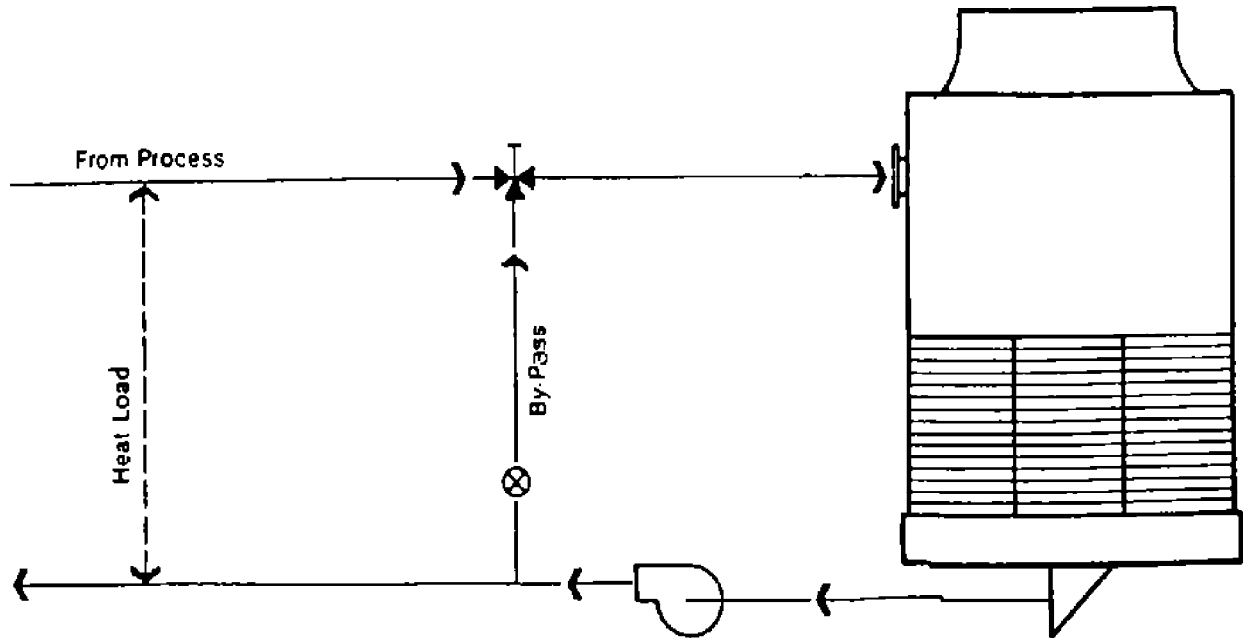


Fig. 12

6.11.3 Provisions for removing scales

If the water which is going to be cooled in the cooling tower, deposits scales in any part of the cooling tower, one or both of the following procedures, shall be followed and relevant equipment and material shall be provided by the Vendor:

- a) Using proper chemicals to wash and clean-out scales.
- b) Using high pressure water streams to remove scale.

6.11.4 Vibration isolation

For the cooling towers that critical situation of excessive vibration exists, properly designed vibration isolators shall be provided.

6.11.5 Provisions for fans stopping when there is no power supply to their motors

Suitable provisions shall be provided by the Vendor to stop fans when there is no power supply to their motor drivers.

6.11.6 Screens for air inlet

In places where ambient air contains excessive amounts of leaves and other debris which are harmful for the cooling tower operation, it may be necessary to provide suitable screens, subject to purchaser's approval, in the air inlet to the cooling tower. These screens shall be prepared and installed in separate removable panels for ease of maintenance and cleaning.

6.12 Performance Tests

Performance tests on the cooling tower shall be done according to CTI Code ATC-105 and relevant ATC-105 addendum. Vendor shall prepare detailed test procedure considering purchaser's comments, and perform the tests in attendance of purchaser. The equipment for performance test shall be provided, calibrated and installed by Vendor. The final test results shall be reported by Vendor. Any deviation from the specified technical characteristics shall be reported and the method to reach to the specified figures and/or performance shall be stated in this report too. Vendor shall be completely responsible to carry out any rectification work in this regard free of charge with the methods described in CTI Codes and/or agreed upon with purchaser. The performance tests shall be carried out after commissioning of the cooling tower and its auxiliary equipment and before provisional acceptance.

6.13 Warranties and Guarantees

Vendor shall be responsible to eliminate any defects encountered during one year operation of the cooling tower and its relevant auxiliary equipment after it is provisionally accepted by the Purchaser. These rectification activities shall be done free of charge and shall be finished within the one year guarantee period after provisional acceptance. The cooling tower and its auxiliary equipment will be finally accepted by purchaser after one year guarantee period is expired and all defects are rectified meeting purchaser's approval.

PART 2 MATERIALS

7. PURPOSE AND GENERAL REQUIREMENTS

This part of standard specifies the minimum requirements for materials of different parts of the cooling towers and relevant components.

In selecting materials for different parts of cooling towers described in this Standard, depending on the specific type of the cooling tower, the applicable clauses of this Part of standard shall be considered:

a) The possibility of using treated wood as the material of any part, shall be declared by the purchaser to the vendor, otherwise vendor shall not use wood in any part of the cooling tower.

b) If wood is going to be used in any part of the cooling tower, the inlet warm water temperature shall be limited to the certain degree not to have mal effect on wood. If reducing the inlet warm water temperature, is not possible due to the main plant's requirements, then it shall be reduced by mixing a proper portion of the outlet cold water with the inlet warm water as typically shown in Fig. 12.

In these cases the cooling capacity of the cooling tower shall be increased to provide the cold water required for mixing with inlet warm water.

c) Plastic materials shall have a flame spread classification of not more than 25 per ASTM-E84.

d) All surfaces which will come in contact with water and water mist, except galvanized and stainless steel surfaces, shall be properly epoxy painted.

e) If the location of cooling tower has a highly hazardous deteriorating condition, wood shall not be used for any part of it, unless otherwise specified by the Purchaser.

8. MATERIALS OF CONSTRUCTION

According to the specific requirements of each project, proper materials shall be selected for different parts of the cooling tower as specified in Clauses 8.1 to 8.22.

8.1 Basin

Unless otherwise specified, basin shall be constructed of proper reinforced concrete.

8.2 Basin Sump

Basin sump shall be constructed of proper reinforced concrete or specified material with enough depth so as the pump not to loose suction.

8.3 Cooling Tower Framework (Structure)

8.3.1 Framework of the field erected cooling towers shall be made using one of the following materials:

- a)** Steel
- b)** Reinforced concrete
- c)** Wood

8.3.2 It shall be noted that if the cooling tower is to be resistant to fire, reinforced concrete shall be selected as the material of framework (Structure). If wood is going to be used for framework of cooling tower, it shall be selected and treated as follow:

- a) Douglas Fir Wood considering CTI bulletin STD-114, shall be selected.
- b) Wood shall be treated according to the CTI STD WMS-112 using acid copper chromate (ACC) treatment.

Prior to treatment, moisture content of the wood shall not exceed 19% for air dried material and 15% for kiln dried material. Deviation from the required penetration or retention, as determined from specimens representative of the condition and dimensions of the tower components to be treated, requires approval of the purchaser. If water born salts are used, seasoning after treatment shall be continued for enough time to complete the chemical reaction within the wood.

8.3.3 Framework of the factory assembled cooling towers shall be either steel or wood. If location of the cooling tower and relevant processes create corrosive conditions, then proper wood can be used subject to purchaser's approval.

8.4 Casing

Casing material shall be selected as follow:

- a) The casing material of the cooling towers with reinforced concrete framework shall be precast concrete panels.
- b) The casing material of the field erected cooling towers with wood or steel framework, shall be fire retardant fiber reinforced polyester corrugated panels.
- c) The casing material of the factory assembled cooling towers, shall be galvanized steel.

8.5 Splash Type Packings

One of the following materials shall be used:

- a) Douglas Fir Wood considering Clauses 8.3.2 (a) and (b) of this Standard shall be used.
- b) polyvinyl chloride may be used in locations where there is a low fire risk.
- c) Stainless steel may be used when totally fireproof material is required.

8.6 Film Type Packings

The material of film type packings shall be high efficiency cellular polyvinyl chloride (PVC).

8.7 Spray Nozzles

The material of spray type nozzles shall be ceramic.

8.8 Louvers

8.8.1 The material of louvers in the field erected cooling tower with reinforced concrete framework shall be precast reinforced concrete or fire retardant fiber reinforced polyester.

8.8.2 The material of louvers in cooling towers with wood framework, shall be properly treated Douglas Fir Wood considering Clause 8.3.2 (a) and (b) of this Standard.

8.8.3 The material of louvers in the factory assembled cooling towers with steel framework, shall be galvanized steel.

8.9 Drift Eliminators

8.9.1 If splash type packings of wood material is going to be used in the cooling tower, then the material of drift eliminators, shall be properly treated wood considering Clauses 8.3.2 (a) and (b) of this Standard.

8.9.2 If packing material is PVC, the material of drift eliminators shall be cellular polyvinyl chloride (PVC).

8.10 Blade of Axial Flow Type Fans

Blade material of axial flow type fans, shall be polyester with fiberglass or aluminum cast according to ASTM B179.

8.11 Blade of Centrifugal Flow type Fans

Blade material of centrifugal flow type fans shall be steel, being hot dip galvanized.

8.12 Fan Hub

8.12.1 Fan hub material shall be so selected that it is structurally compatible with blade weight and loading.

8.12.2 One of the following material shall be selected as the hub material:

- a) Galvanized structural steel.
- b) Ductile cast iron (ASTM-A 536) galvanized per ASTM-A153.
- c) Gray iron casting.
- d) Wrought or cast aluminum.

For brackish and sea water services, zinc coated hubs shall be coated with two coats of coal tar polyamide epoxy 400 μm total nominal dry film thickness.

8.12.3 If different metallic materials are going to be used for fan blade and hub, they shall be separated from each other to prevent galvanic corrosion.

8.13 Fan Deck

8.13.1 The fan deck material shall be compatible with framework material.

8.13.2 For cooling towers with wood framework, the fan deck material, shall be tongue and groove fir plywood.

8.13.3 For cooling towers with reinforced concrete framework, the fan deck material, shall be prestressed double-tee sections.

8.13.4 For cooling towers with steel framework, the fan deck material shall be galvanized steel. In this case for brackish and sea water services, fan deck shall be coated with two coats of coal tar polyamid epoxy 400 μm total nominal dry film thickness.

8.14 Fan Stack (Cylinder)

One of the following materials shall be selected as the fan stack (cylinder) material depending on the framework material:

8.14.1 For cooling towers with all different materials of framework, fan stack material may be fiber reinforced plastic.

8.14.2 For cooling towers with wood framework, properly treated wood shall be used.

8.14.3 For cooling towers with steel framework, steel fan stack shall be used.

8.15 Fan Shaft, Discs, Flexible Coupling, and Bolting

These components shall be stainless steel Type 304 or Type 316. For brackish and sea water services these components shall be stainless steel Type 316.

8.16 Hardware (Bolts, Nuts, Washers, Nails, Lag Screws and Washers)

Fan bolts and hardware shall be made of carbon steel, galvanized per ASTM-A 123. For brackish and sea water services, these components shall be made of Type 316 stainless steel.

8.17 Supports and Guards for Mechanical Equipment, Electric Motor Support, Ladders, Safety Cages and Gratings

All above mentioned components shall be carbon steel, hot dip galvanized per ASTM-A 123. For brackish and sea water services, zinc coated carbon steel for mechanical equipment supports and guards, shall be coated with two coats of coal tar polyamid epoxy 400 µm total nominal dry film thickness.

8.18 Packings Supports and Hangers

The supports and hangers of the splash type packings with PVC and stainless steel materials and film type packings shall be stainless steel. The supports and hangers for the splash type packing with wood material, shall be properly treated wood.

8.19 Tower Supports

The cooling tower supports shall be made of reinforced concrete or steel depending on the Purchaser's approval.

8.20 Risers, Manifolds, Reducers and Distributors

These components shall be hot-dip galvanized steel.

8.21 Risers and Trash Racks Including Frame

8.21.1 For fresh water services these components shall be carbon steel galvanized per ASTM-A 123.

8.21.2 For brackish and sea water services these components shall be stainless steel Type 316. In these cases means of protecting hardware from crevice corrosion, such as cathodic protection by carbon steel, shall be provided.

8.22 Gear (Speed Reducer) Casing

8.22.1 For fresh water services, it shall be cast or ductile iron properly galvanized.

8.22.2 For brackish and sea water services, it shall be cast or ductile iron properly galvanized and coated with two coats of coal tarpolyamide epoxy 400 µm total nominal dry film thickness.

APPENDICES

**APPENDIX A
INFORMATION TO BE PROVIDED BY THE PURCHASER**

A.1 Location of Site

- | | | |
|------------------------------------|-------|-------|
| a) National grid ref. or equipment | ..... |  |
| b) Height above ground level | ..... | m |
| c) Height above sea level | ..... | m |
| d) Maximum expected wind speed | ..... | m/sec |
| e) Speed of prevailing wind | ..... | m/sec |
| f) Direction of prevailing wind | ..... |  |

A.2 Site Details

- | | | |
|---------------------------------------|-------|-----|
| a) Available area: | | |
| - Length | ..... | m |
| - Width | ..... | m |
| b) Height limit: | | |
| - min. | ..... | m |
| - max. | ..... | m |
| c) Any other restrictions | ..... |  |
| d) Drawing of tower location attached | ..... | yes |

A.3 Lifetime of the Cooling Tower and its Type

- | | | |
|------------------------|-------|-------|
| a) Lifetime | ..... | years |
| b) Type ⁽¹⁾ | | |

A.4 Restrictions on Unit Size ⁽²⁾

- | | | |
|--|-------|----|
| a) Number of towers | ..... |  |
| b) Maximum lifetime mass | ..... | kg |
| c) Maximum operating mass | ..... | kg |
| d) max. permissible size of largest section: | | |
| - Length | ..... | m |
| - Width | ..... | m |
| - Height | ..... | m |
| e) Are they required with basins? | ..... |  |

(to be continued)

APPENDIX A (continued)

A.5 Preliminary Duty of Each Tower (Design Conditions)⁽¹⁾

- | | | |
|------------------------------------|-------|-------------------|
| a) Water flow | ..... | m ³ /h |
| b) Inlet water temperature | ..... | °C |
| c) Outlet water temperature | ..... | °C |

A.6 Ambient Air Conditions⁽⁴⁾

- | | | |
|---|-------|----|
| a) max. dry bulb temperature | ..... | °C |
| b) min. dry bulb temperature | ..... | °C |
| c) max. wet bulb temperature | ..... | °C |
| d) min. wet bulb temperature | ..... | °C |
| e) max. relative humidity | ..... | % |
| f) min. relative humidity | ..... | % |
| g) Is sand storm happening at site? | ..... |  |
| h) Size of biggest particles in air | ..... |  |
| i) Size of smallest particle in air | ..... |  |
| j) Amount of particles in air (%): | ..... |  |
| - By volume | ..... | % |
| - By weight | ..... | % |
| k) preliminary ambient air design conditions: ⁽¹⁾ | | |
| - Dry bulb temp. | ..... | °C |
| - Wet bulb temp. | ..... | °C |
| - Relative humidity | ..... | % |

A.7 Electricity supply

- | | | |
|---------------------------|-------|-------|
| a) Voltage | ..... | V |
| b) Phase | ..... |  |
| c) Frequency | ..... | C/sec |
| d) Available power | ..... | kW |

A.8 Noise

The system shall be designed and provided to comply with this Standard yes

A.9 Details of Water

- | | |
|---|-------|
| a) Type | ..... |
| b) Source | ..... |
| c) The variation of water analysis and temperature during different times of the year (if any) shall be as stated below: | |

.....

(to be continued)

APPENDIX A (continued)

d) Maximum inlet water temperature	.....	°C
e) Minimum inlet water temperature	.....	°C
f) Maximum acceptable outlet water temperature	.....	°C
g) Minimum acceptable outlet water temperature	.....	°C
h) Water supplier	.....
i) Preliminary recommended details of intended water temperature (if known) shall be as follows: ⁽¹⁾	
	
	
	
j) Recommended purge rate ⁽¹⁾	L/sec
k) Mains pressure available for make up	.....	kPa
l) Head pressure available at tower inlet	.....	kPa
m) Expected contamination	.....
n) Basin:		
1) The basin design shall be done by	.....
2) The material shall be provided by	.....
o) Inlet and outlet pipe characteristics available at site:		
1) Inlet:		
- Number	.....
- Nominal size	.....
- Material (relevant standard)	.....
- Any flange available	.....
- Flange material (relevant standard)	.....
- Location	.....
2) Outlet:		
- Number	.....
- Nominal size	.....
- Material (relevant standard)	.....
- Any flange available	.....
- Flange material (relevant standard)	.....
- Location	.....
p) Make up water		
- Temperature	.....	°C
- Pressure	.....	kPa
- Quantity ⁽³⁾	L/sec
- Source	.....
- Analysis shall be as follows:	.....
	
	
	

(to be continued)

APPENDIX A (continued)

A.10 Indoor Tank Method

a) Is there any possibility to use indoor tank method?

b) The location of indoor tank and available space will be as follows:

.....

A.11 Is there any possibility to use wood in any part of the cooling tower?

A.12 Is it necessary to provide side stream filtration for basin water?⁽¹⁾

Notes:

1) They will be finalized during contract execution.

2) Any restrictions, particular to the site, shall be made clear. Particular attention shall be drawn to the followings:

- Restricted access for delivery vehicles.
- Restricted access for cooling towers into building.
- Building design restrictions to air movement.
- Details of adjacent chimneys, discharge ventilation fans or process discharges and other heat sources and equipment consideration shall be given to possible environmental heat gain which may increase the wet bulb temperature of the air at intake of the cooling tower.

3) This quantity is the maximum available and Vendor shall optimize the consumption considering this Standard.

4) Complete details of the meteorological data shall be provided by purchaser and submitted to the Vendor as a part of this Appendix.

**APPENDIX B
INFORMATION TO BE PROVIDED BY VENDOR**

- B.1** Preliminary proposed type of tower⁽¹⁾
- B.2** Number of towers
- B.3** Number of cells in each tower
- B.4** Maximum lifting/operating mass of tower kg/kg
- B.5** Lifetime of cooling tower and its auxiliaries years
- B.6** Dry mass of each tower kg
- B.7** A mass distribution diagram is enclosed yes
- B.8** Maximum size of largest section:
- Length m
- Width m
- Height m
- B.9** Design of basin will be done by
- B.10** Material of basin will be supplied by
- B.11** Preliminary duty of each tower (design conditions):⁽¹⁾
- a)** Water flow m³/hr
- b)** Inlet water temperature °C
- c)** Outlet water temperature °C
- B.12** Preliminary proposed packings:⁽¹⁾
- a)** Type
- b)** Material
- B.13** Casing:
- a)** Material
- b)** Protective treatment
- B.14** Fans:
- a)** Type
- b)** Number in each tower
- c)** Fan static pressure kPa
- d)** Fan speed rpm
- e)** Handling wet of ambient air
- f)** Manufacturer

(to be continued)

APPENDIX B (continued)

B.15 Motors:

- a) Number per tower
- b) Absorbed power by each motor kW
- c) Rated power of each motor kW
- d) Speed rpm
- e) Electricity supply:
 - Voltage V
 - Phase
 - Frequency Hz
- f) Frame size
- g) Enclosure
- h) Manufacturer
- i) Inside wet stream (yes/no)
- j) Outside wet stream (yes/no)

B.16 Drive details will be as follows:

.....

B.17 Distribution system:

- a) Type
- b) Minimum pressure at tower inlet kPa

B.18 Drift eliminators:

- a) Material
- b) Expected drift loss %

B.19 Purge rate⁽¹⁾ L/sec

B.20 Required make up:⁽¹⁾

- Pressure kPa
- Temperature °C
- Flow L/sec
- Analysis shall be as follows:

.....

B.21 Noise:

The system shall be designed and provided to comply with this Standard

B.22 All information listed in Appendix A, items A.9, A.10 and A.11 shall be provided and listed herebelow by the Vendor:

(to be continued)

APPENDIX B (continued)

The filling by the Vendor:

(to be continued)

APPENDIX B (continued)

The filling by the Vendor:

(to be continued)

APPENDIX B (continued)

B.23 The ambient air design conditions: ⁽¹⁾ :

- Dry bulb °C
- Wet bulb °C
- Relative humidity %

B.24 Materials (the relevant standards for materials and coatings shall be mentioned):

- a) Basin
- b) Basin sump
- c) Framework
- d) Casing
- e) Packing
- f) Spray nozzles
- g) Louvers
- h) Drift eliminators
- i) Fan blade
- j) Fan hub
- k) Fan deck
- l) Fan stack
- m) Fan shaft, discs, flexible coupling and belting
- n) Hardware
- o) Supports and guards for mechanical equipment
- p) Support for electric motors
- q) Packings supports
- r) Hangers
- s) Tower support
- t) Risers
- u) Manifolds
- v) Reducers
- w) Screens including frame
- x) Trash racks including frame
- y) Gear casing
- z) The materials of other parts shall be specified herebelow:

<u>Name of Part</u>	<u>Material</u>
.....
.....
.....
.....
.....
.....
.....

B.25 Freeze Protection:

- a) Are two speed fans provided?
- b) Are fans stopping provided?
- c) Are fans reversing provided?
- d) Are fans speed control provided?

(to be continued)

APPENDIX B (continued)

- e) Are fans with variable pitch?
- f) Is preheating of the inlet air with hot water bypass provided?
- g) Are adjustable inlet air louvers provided?
- h) Is reducing the numbers of packings cells provided?
- i) Prevention of basin water from freezing:
- Basin draining
- Indoor tank method
- Electric immersion heater or steam heating methods
- Bypass circulation method

B.26 The provisions provided in the system for the followings shall be described in the empty space below:

a) Reducing the drift effects:

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b) Reducing the blow out nuisance:

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c) Reducing the fogging and plume nuisance:

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d) Blow down and draining:

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e) Noise level:

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.....

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(to be continued)

APPENDIX B (continued)

f) Access to different parts:

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g) Fire prevention:

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.....
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h) Outlet water temperature lower limit:

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.....
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i) Maximum inlet water temperature:

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j) Removing scale:

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k) Vibration isolation:

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l) Fans stopping where there is no power supply to their motors:

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(to be continued)

APPENDIX B (continued)

m) Screen for air inlet:

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n) Interference problem:

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o) Recirculation problem:

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p) Water treatment:

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Note:

⁽¹⁾They will be finalized during contract.

APPENDIX C

CONSIDERATION ON SOME FACTORS AFFECTING RECIRCULATION

C.1 Tower Shape and Orientation with Prevailing wind

Considering the speed and direction of prevailing wind, the cooling tower shall be located in a way that relatively lower pressure area is not created on none of the open sides of inlet air to the cooling tower to prevent the outlet air being recirculated and affecting the inlet air temperature. If this concept can not be implemented, one of the following methods, after technical and cost evaluation, shall be selected:

- a)** If rectangular, induced type cooling tower is going to be selected, it shall be divided into several cooling towers having less length with significant air space in between. Length to width ratio shall be about 5 to 1.
- b)** The cooling tower shape shall be changed from rectangular to circular or octagonal one. It is notable that circular or octagonal induced type cooling towers are more sensitive to interference problem, therefore if this shape is going to be selected provisions to face with interference effect shall be provided.
- c)** Changing the height of cooling tower or adopting natural or fan assisted natural draught instead of induced type cooling tower which causes decreasing the recirculation rate due to discharging warm air at higher levels.
- d)** In single flow rectangular mechanical draught cooling towers, where there is only one open area for air intake, the open area shall be positioned broad side to the prevailing wind direction.

C.2 Air Discharge Velocity

The velocity of air leaving the fans of induced type cooling towers shall be optimized to decrease the recirculation rate to the acceptable amount.

This speed shall not increase excessively because it needs either more input power or longer fans stacks (cylinders).

C.3 Height and Spacing of Fans Stacks (Cylinders)

Longer fan stacks have lower recirculation. This concept shall be considered as far as technically and economically preferable in comparison with other methods. suitable spacing shall be provided between fans stacks to create less restricted wind flow between them.

C.4 Density Difference Between Exit Air and Ambient Air

The density difference between exit air and ambient air shows the tendency for exit air to come down and probably causing recirculation in certain types of cooling towers depending on the prevailing wind direction, location of the cooling tower and other factors affecting recirculation.

ATTACHMENTS

1. TYPES OF COOLING TOWERS

In addition to the description in Clauses 1.1 to 1.4 given below, the definition given in Clause 4 of BS 4485: Part 3:1988 also shall be used in determining the types of cooling towers for a definite project and location.

1.1 Natural Draught Cooling Towers

In these type of cooling towers the air flow rate is dependent on natural wind forces, cooling tower height, ambient air temperature and restrictions made by the tower casing and shell and the tower internal and external equipment. This type of cooling tower can be either counterflow or crossflow type.

In counterflow type coolers the air and water flow directions are opposite to each other while in crossflow type coolers the air direction is perpendicular to water flow direction. Typical diagrams of these types of coolers are shown in Figs. 1 (a) and (b) respectively.

1.2 Mechanical Draught Cooling Tower

1.2.1 Forced draught counterflow cooling tower

In this type of cooling tower the air flow rate depends upon the fans characteristics and tower internal equipment. This type of cooling tower shall not be used in places where there is a freezing hazard, because of possibility of icing on fan blades and consequently causing unbalance of fan which shall be avoided. This type of cooling tower in these areas shall be used for indoor or enclosure installations with ductwork for air intake (if necessary). Since normally centrifugal type fans are used in this type of cooling towers, a higher static pressure will be exerted by fan enabling to intake air to the fan through suitable ducting and minimizing the recirculation effect. Fig. 2 shows a typical arrangement of this type of coolers.

1.2.2 Induce draught crossflow and counterflow cooling tower

The air flow in this type of cooling towers also depends on fan characteristics and restrictions made by cooling tower equipment. Fans shall be installed in the air flow stream after tower internal equipment. Figs. 3, 4, 5, 6, 7(a) and (b) are typical arrangements of different types of this type of cooling tower.

In circular and octagonal induced type of cooling towers interference matter shall be carefully reviewed to optimize it by taking preventive actions.

1.3 Fan Assisted Natural Draught Cooling Tower

This type of cooling tower is a combination of natural and mechanical draught cooling towers. It shall be properly designed and selected to obtain the following advantages:

- a) Lowest possible operation cost, because the draught provided by stack height will be achieved without any power input, therefore operating cost will be lower. However the cost evaluation and analysis of capital, maintenance and operation costs, sometimes prove that this type of cooling tower is the most economical one.
- b) A properly designed cooling tower may necessitate to use fans only when ambient temperature is more than a limited value.
- c) In places where plume shall be as low as possible, this type of cooling tower may be a solution.

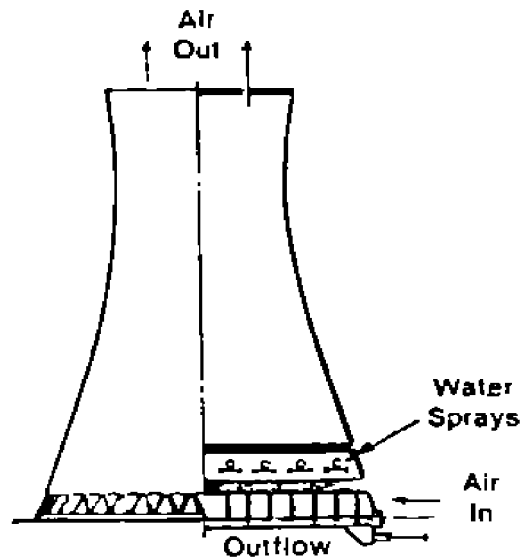
A typical arrangement of this type of cooling tower is shown in Fig. 8.

1.4 Field Erected Cooling Towers

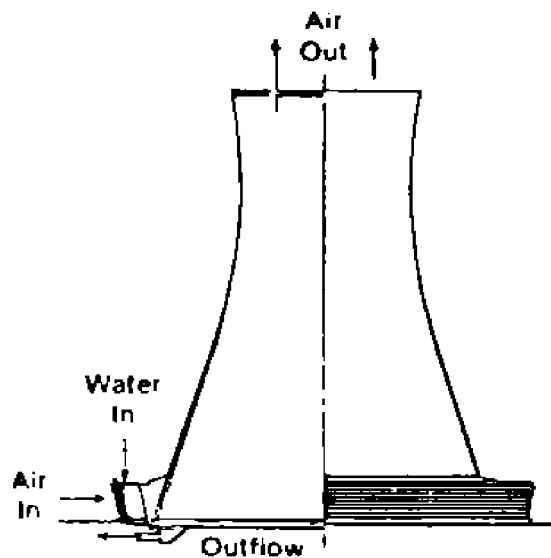
In this type of cooling towers the primary construction activities take place at the site. All big cooling towers, and many of the smaller towers are prefabricated, piece marked and shipped to the site for final assembly. Supervision for final assembly is usually provided by the Vendor, if requested by purchaser.

1.5 Factory Assembled Cooling Towers

In this type of cooling towers complete assembly will be done at manufacturer's shops, but according to the shipment limitations, bigger towers will be separated to different parts for easiness of shipment (if necessary), and then assembled at site again. Factory assembled towers are also known as packaged or unitary, towers.

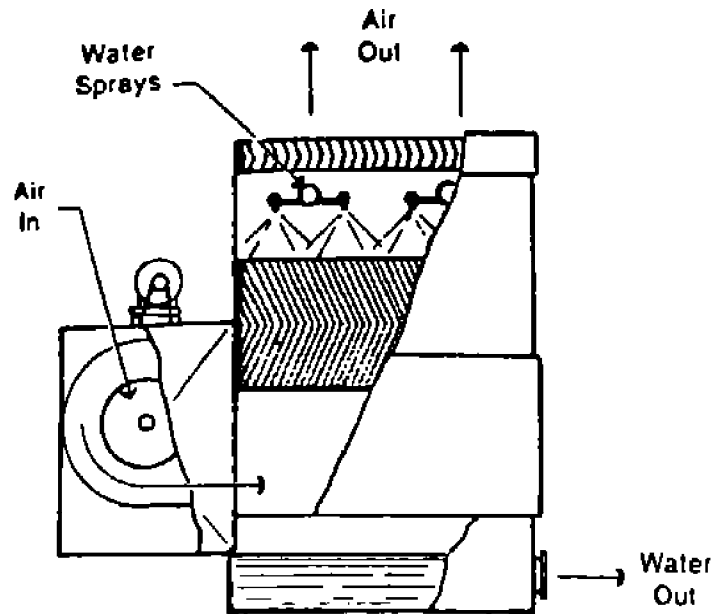


a) Counterflow type cooling tower

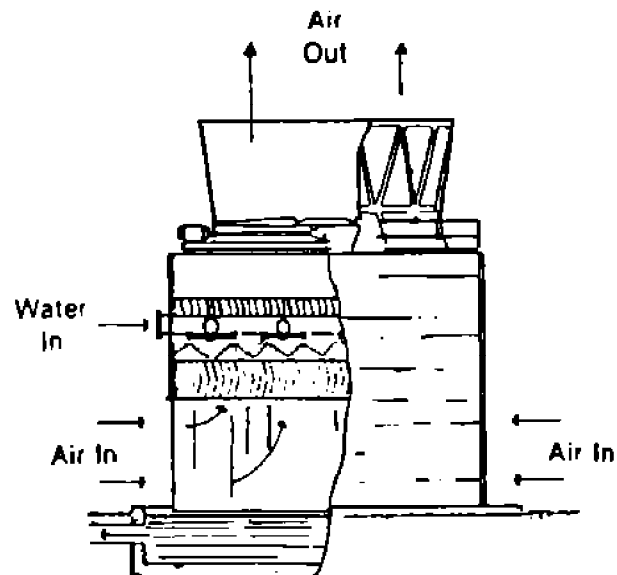


b) Crossflow type cooling tower

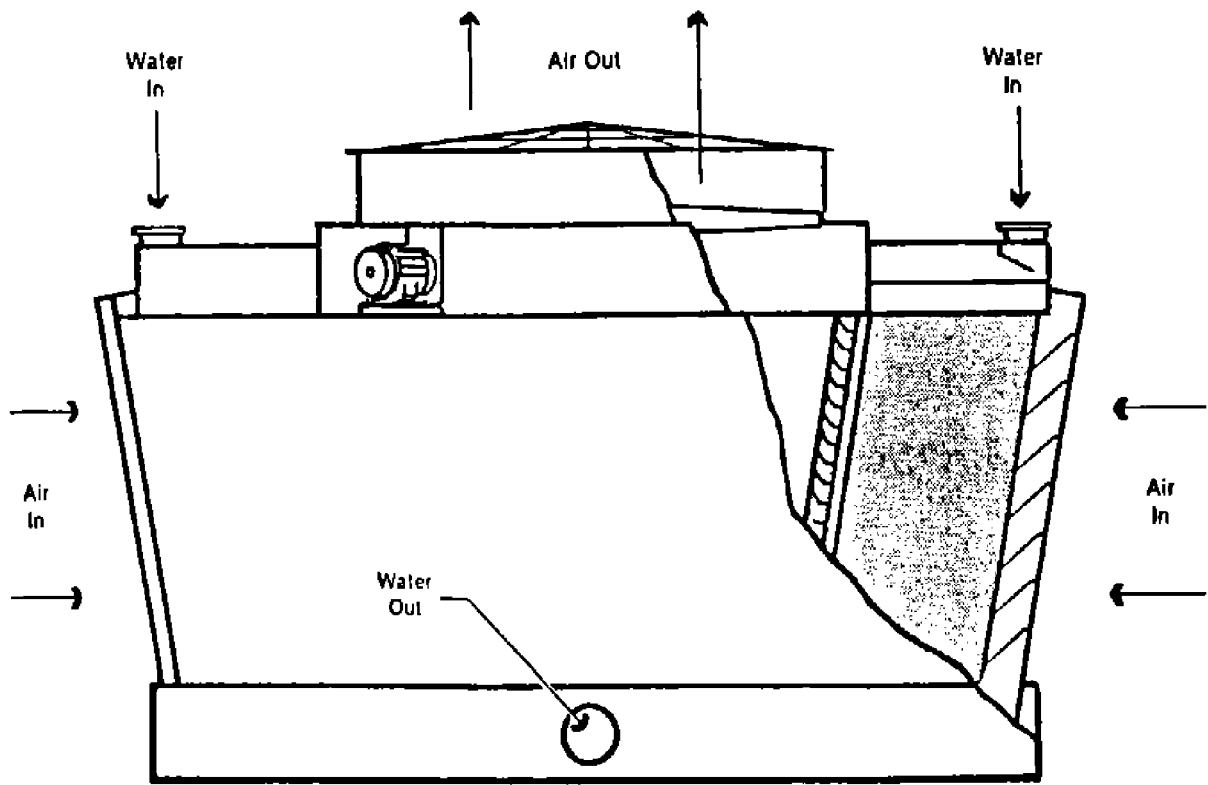
Fig. 1



FORCED DRAUGHT COUNTERFLOW COOLING TOWER
Fig. 2

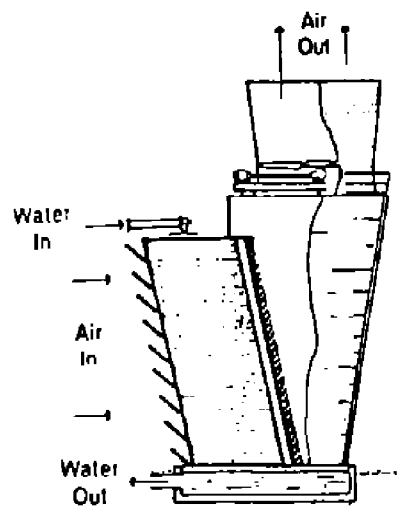


INDUCED COUNTERFLOW TYPE COOLING TOWER
Fig. 3



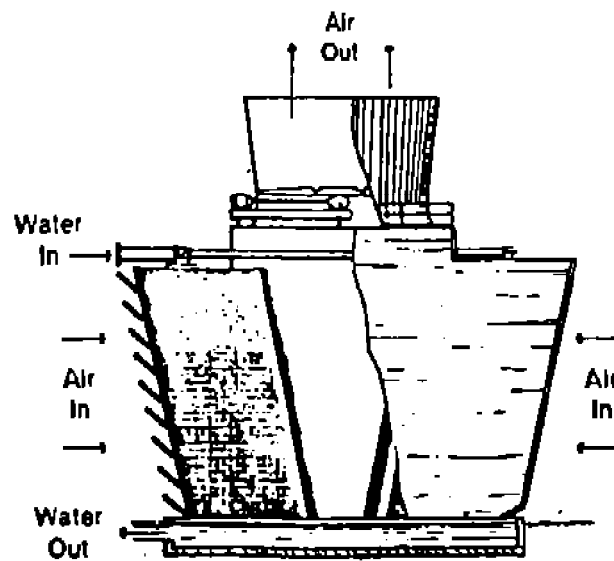
INDUCED CROSSFLOW TYPE COOLING TOWER

Fig. 4

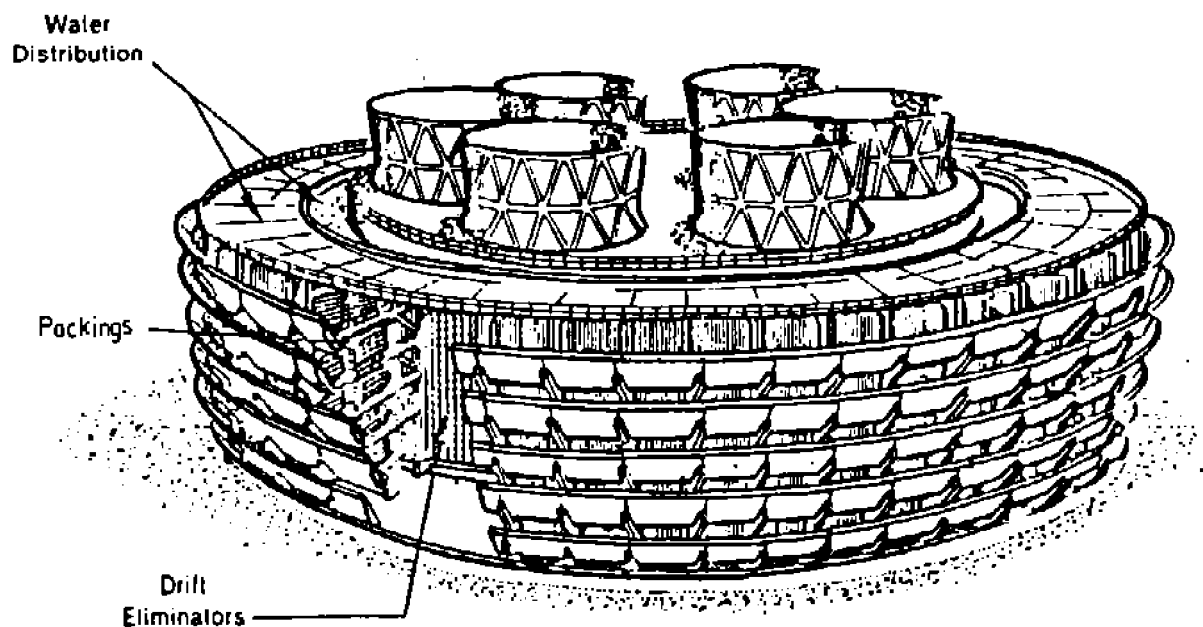


SINGLE FLOW INDUCED CROSSFLOW TYPE COOLING TOWER AIR INTAKE IS FROM ONE SIDE ONLY

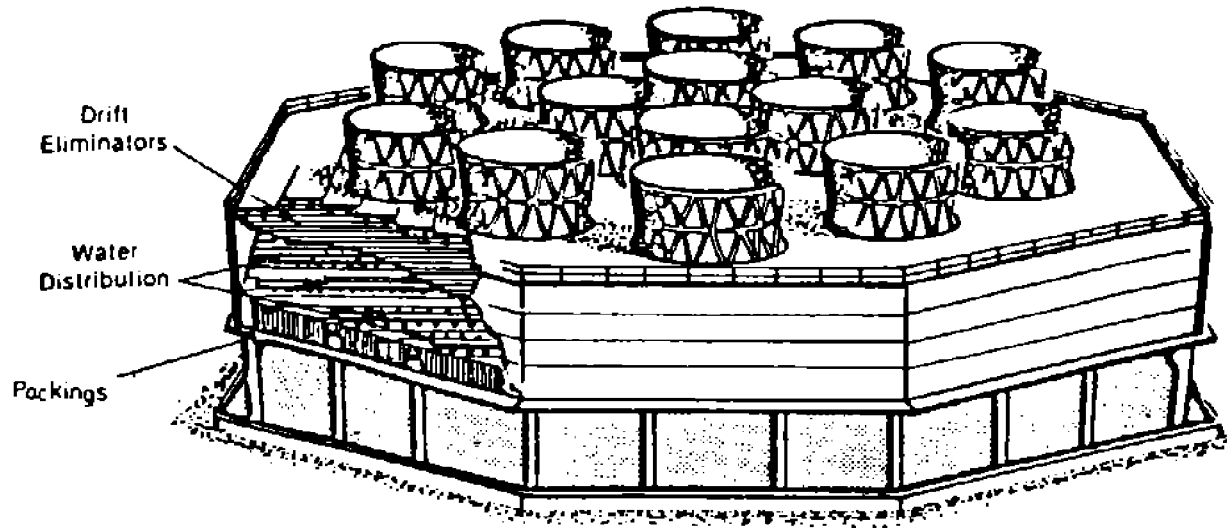
Fig. 5



DOUBLE FLOW INDUCED CROSSFLOW TYPE COOLING TOWER
AIR INTAKE IS FROM TWO SIDES
Fig. 6

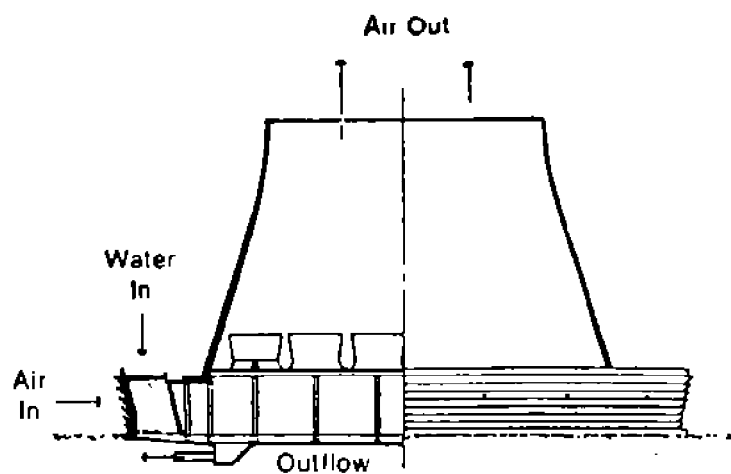


- a) Circular induced crossflow type cooling tower. Air intake is from all sides with the lowest recirculation effect.



- b) Octagonal induced counterflow type cooling tower. Air intake is from 8 sides with the lowest recirculation effect.

Fig. 7



FAN ASSISTED NATURAL DRAUGHT COOLING TOWER

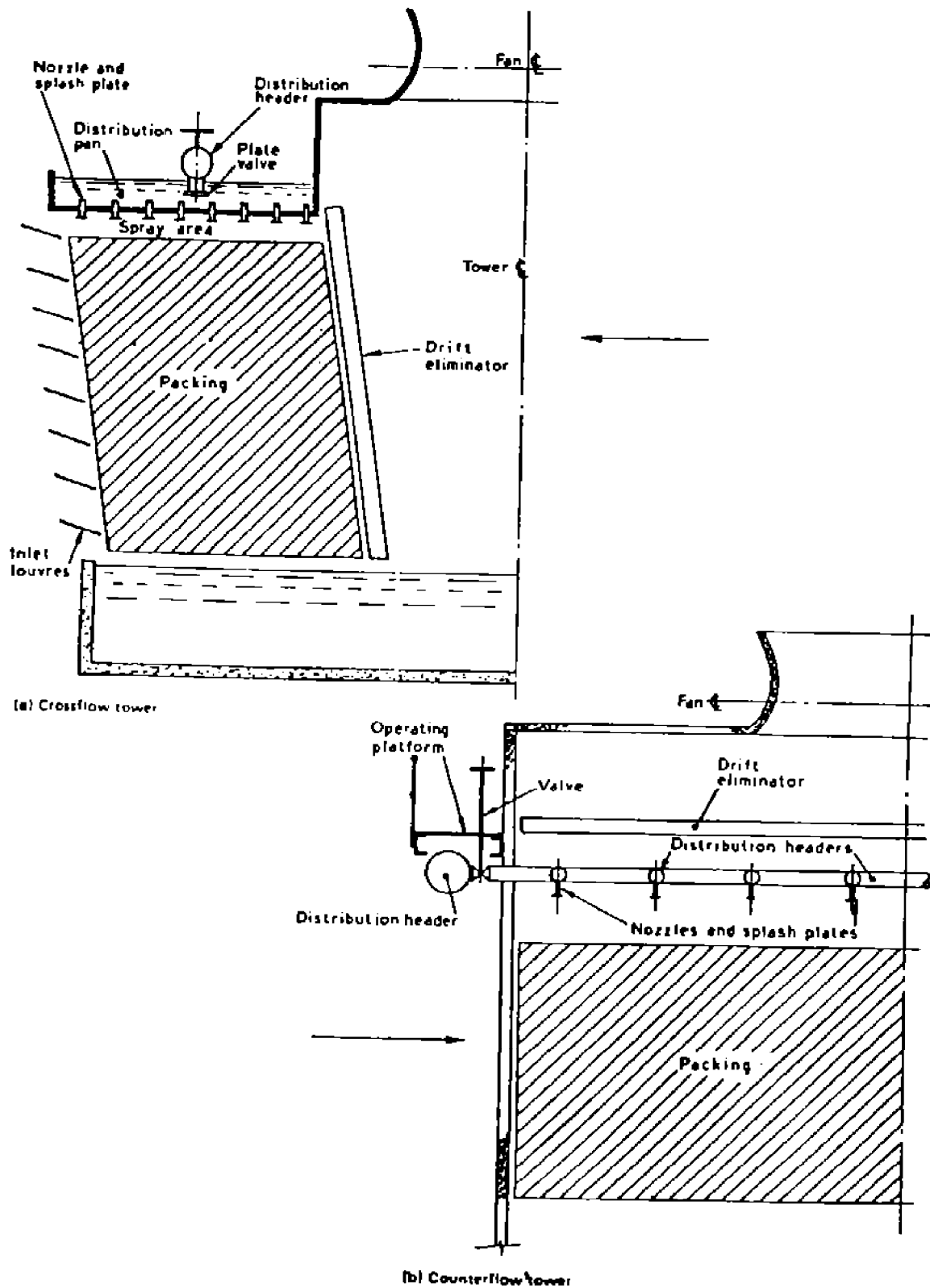
Fig. 8

2. EFFECT OF ALTITUDE

Altitude has effect on design and selection of cooling tower due to change in ambient air pressure resulting change of moisture content and hence, enthalpy value of air which causes change in the cooling capacity of the cooling tower.

3. TYPICAL ARRANGEMENTS OF WATER DISTRIBUTION SYSTEMS

Typical arrangements of water distribution systems are shown in Figs. 9 to 13.



WATER DISTRIBUTION SYSTEM FOR INDUCED CROSS AND COUNTER FLOW TYPE MECHANICAL DRAUGHT COOLING TOWER

Fig. 9

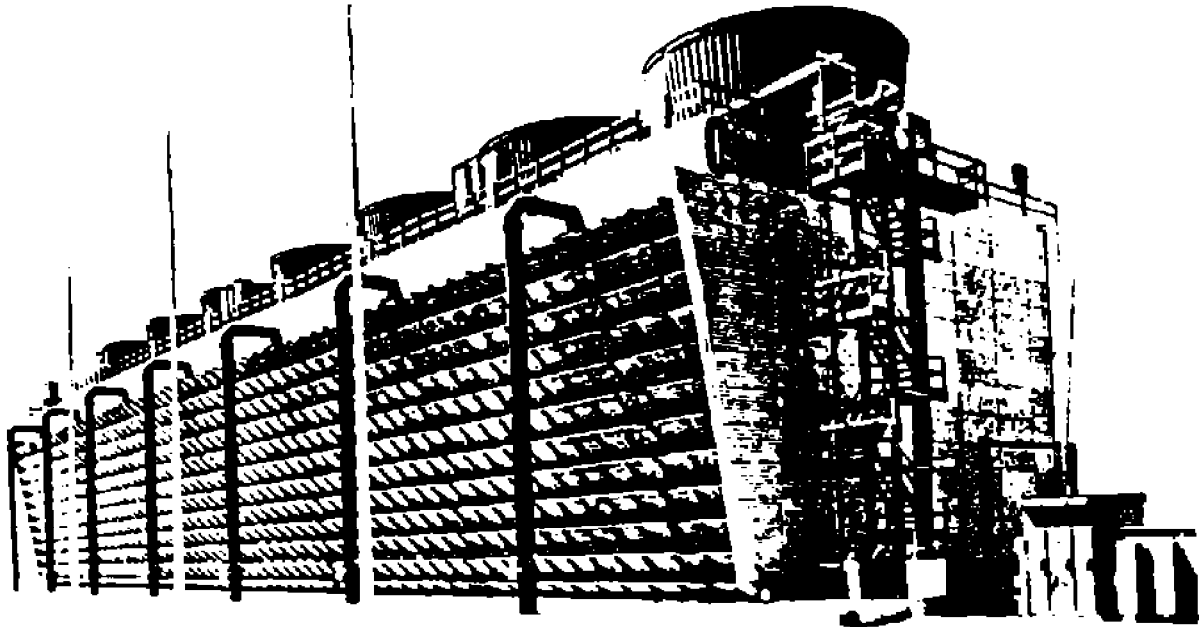


Fig. 10

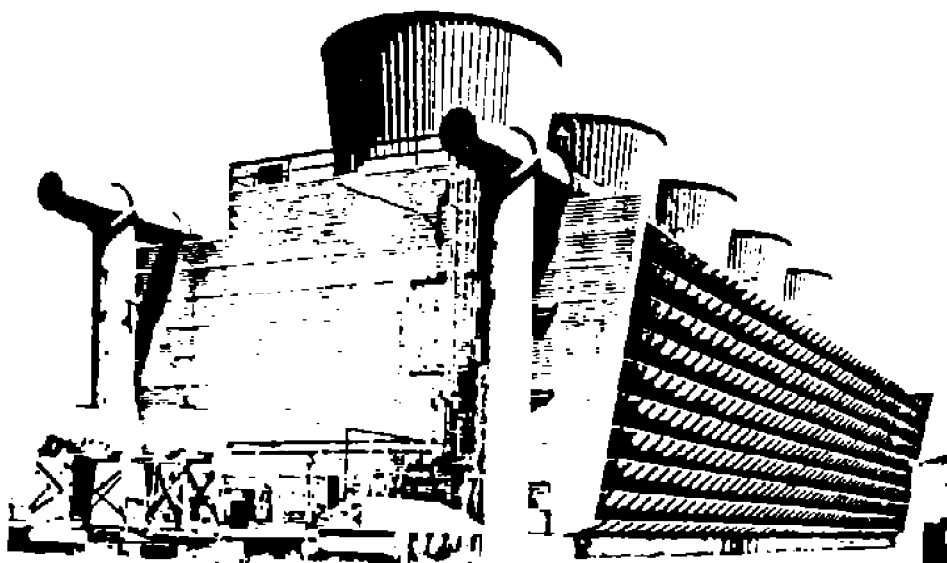


Fig. 11

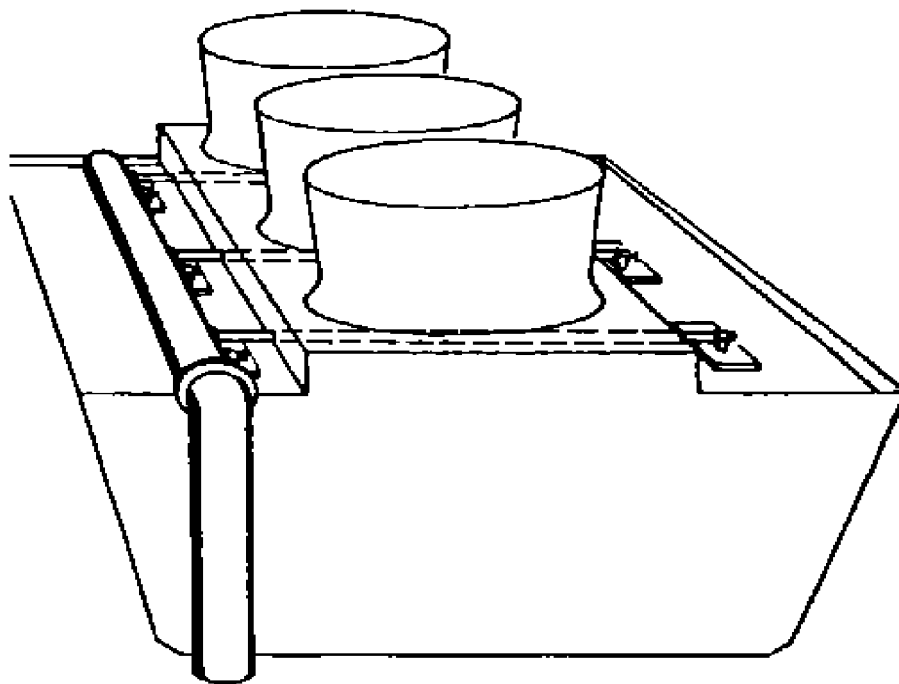
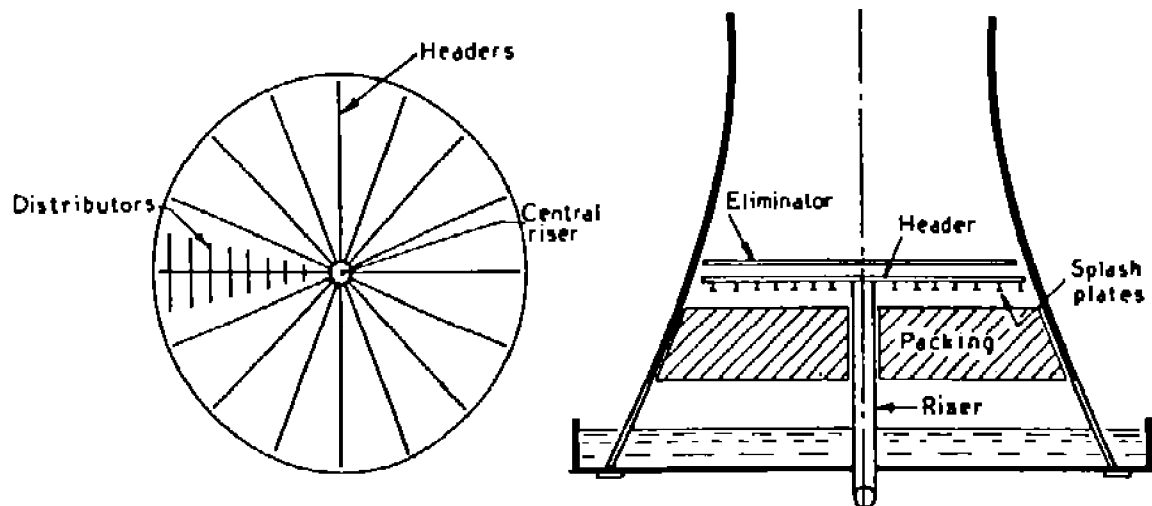
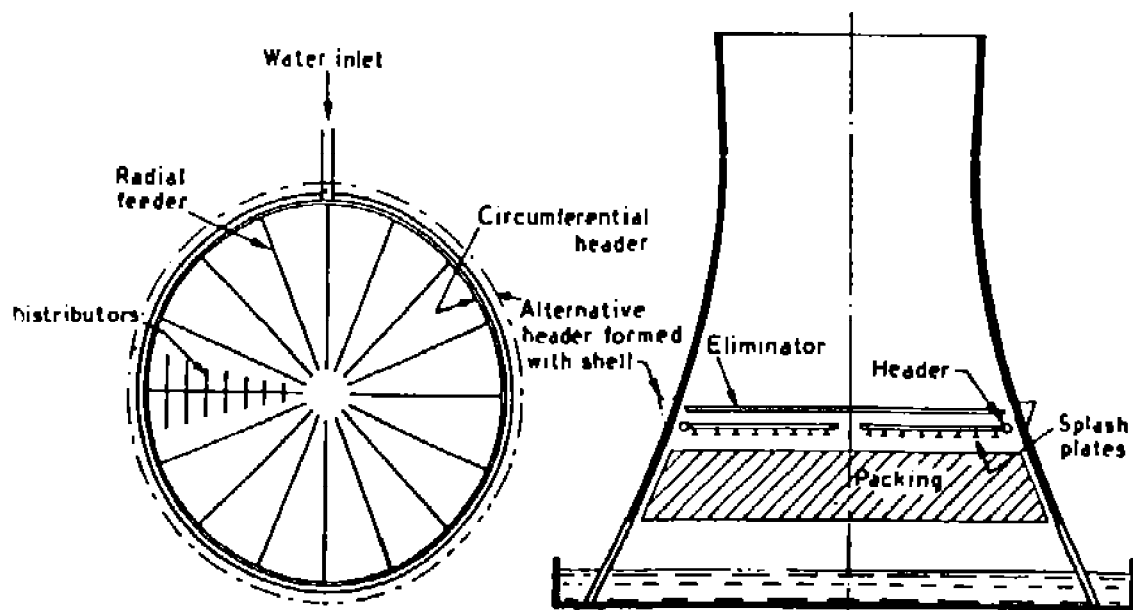


Fig. 12



a) Central riser, radial feed



b) Circumferential header, radial feed

Fig. 13