## 8.5 COOLING TOWER THERMAL PERFORMANCE TESTING (ID Cooling Tower)

### 8.5.1 Introduction

Cooling water system plays a vital role in dissipation of waste heat in power station. More than 60 % of total heat input to the plant is finally dissipated as waste heat. The waste heat from the power plant is carries away by circulating water and ultimately gets dissipated in cooling tower.

### 8.5.2 Objective

The purpose of this test to describe procedure for testing and performance evaluation of Cooling Tower.

### 8.5.3 Salient Terms Used in CT Testing

#### 8.5.3.1 Approach :

Difference between the Cold Water Temperature at CT outlet and Inlet air Wet Bulb Temperature

#### 8.5.3.2 Range :

Difference between the Hot Water Temperature (inlet to CT) and Cold Water Temperature (outlet of CT)

#### 8.5.3.3 Tower Capability:

The most reliable means to assess the cooling tower thermal performance is tower capability. It is defined as the percentage of water that the tower can cool to the design cold water temperature when the inlet wet-bulb, cooling range, water flow rate and fan motor power are all at their design value.

#### 8.5.3.4 Effectiveness:

Effectiveness of Cooling Tower = Range*100 /(Range + Approach)

### 8.5.4 Test procedure

#### 8.5.4.1 Plant specific Data and Characteristic curves

Reference curves provided by manufacturer (wet bulb temperature vs cold water temperature) for different design ranges and at 90%, 100%

and 110% of circulating water flow are required for evaluation of Tower capability.

**8.5.4.2 Parameters to be measured**

i) Wet Bulb Temperature (WBT) at Tower inlet
ii) Cold Water Temperature at CT outlet
iii) Hot Water Temperature at CT inlet
iv) CW Flow to each Tower
v) Fan Motor Power

**8.5.4.3 Test Conditions**

The following variations from design condition shall not be exceeded

| | | |
|---|---|---|
| 1 | CW Flow rate | 90 – 110% of Design |
| 2 | Cooling Range | 80 – 120% of Design |
| 3 | Wet-bulb Temp | Design +/- $8.5^0$ C |
| 4 | Fan Motor Power | 90 – 110% of Design |
| 5 | Wind Velocity: | Average: 4.5 m/s<br>One-Minute Duration: 7.0 m/s |

**8.5.4.4 Duration of test**

The test will be started after reaching steady state condition.

**8.5.4.5 Frequency Of reading**

**Test Parameters And Frequency Of Test Readings**

| S.No | PARAMETERS | MIMINUM READING / HOUR / STATION |
|---|---|---|
| 1 | Inlet Air Wet Bulb Temperature | 6 |
| 2 | Hot Water Temperature | 6 |
| 3 | Cold Water Temperature | 6 |
| 4 | Circulating Water Flow | 1 |
| 5 | Wind Velocity | 4 |

### 8.5.4.6 Constancy Of Test Condition

Variation In test condition shall be within the following limits
Circulating water flow shall not vary by more than 2 %
Heat load should not vary more than 5 %

### 8.5.4.7 INSTRUMENTS, LOCATION & METHOD OF MEASUREMENTS

#### 8.5.4.7.1 Wet Bulb Temperature

WBT is measured at the air inlet side on both side of tower. Two locations are fixed, one on each side of he tower .The location of the measurement should be within 1.5 m from the air intake to the tower. Hand held Phychrometers are used for measurement. The thermometers shall be graduated in increments of not more than 0.1˚C and the accuracy should be in the range of 0.05˚C.
A minimum of 6 readings/hour should be taken on each location. The average of all the readings on both the side locations is taken as WBT for the evaluation of the test result.

#### 8.5.4.7.2 Cold Water Temperature

The recooled water temperature can be measured directly at the point where the circulating water is discharged from the basin, the average cold water temperature being determined by simultaneous test readings taken across the selected sections. The measurement location is selected such that proper mixing of the cold water is ensured. For getting representative measurement the cold water temperature, grid arrangement (see Fig 8.5.1) may be made at measuring locations across the cold water channel. RTD's may be installed at 4-5 locations, across the horizontal plane and temperature readings taken using digital temperature read out connected to RTD'S.

#### 8.5.4.7.3 Hot Water Temperature

Hot water temperature measurement shall be made in the tower risers or at the discharge of inlet risers into the flume or distribution system or for a multi-cell tower in the supply header just upstream of the first riser. If the source is a mixture of two or more streams of different temperatures, complete mixing must be ensured at the point of measurement.
Thermometers can be used for measurement of Hot water temperature. The thermometers may be inserted into the channel where water distribution network is open or into the thermo wells provided on the duct as the case may be 2-3 locations may be selected at each locations

and average of all the readings is taken as the hot water temperature for evaluation

The indicator of the thermometer used for measurement shall be graduated in increments of not more than 0.1 ˚C

**8.5.4.7.4 Circulating Water Flow**

Wherever adequate upstream and down stream straight lengths are available suitable calibrated pitot probes, shall be used for the flow measurement.

For obtaining swirl free and fully developed flow condition the minimum upstream and downstream straight lengths at the measuring cross section shall be 20 pipe diameter and 5 pipe diameter respectively. To meet the above criteria, it will be necessary to provide the stubs along with the isolating valves in the underground / above ground portion of water pipe / ducts carrying hot water to the tower. Provision shall be made for traversing two diameters, at right angles to each other.
For the measurement of differential pressure, water manometer connected to the pitot shall be used.

**8.5.4.7.5 Flow Measurement using Pitot traverse**

Pitot traverse is done in two planes i.e. vertical and horizontal at 90 degrees to each other. The required ports for pitot insertion are to be made at suitable location in the hot CW duct as described above. For mapping the dp within the duct the pitot is inserted into the duct in the vertical plane and dp noted down using a water manometer connected to the pitot. The no of insertion points for the pitot varies with the size of the duct. Forb pipes / ducts less than 500 mm size, 10 insertion per plane is required and for pipe / ducts above 500mm size, 20 insertions per plane is required. The locations at which the dp is to be measured is given in format 8.5.1. The dp measurement is repeated in the horizontal plane also and the average dp value is taken for computation of CW flow.

Grid Arrangement For Cold Water Temperature Measurement

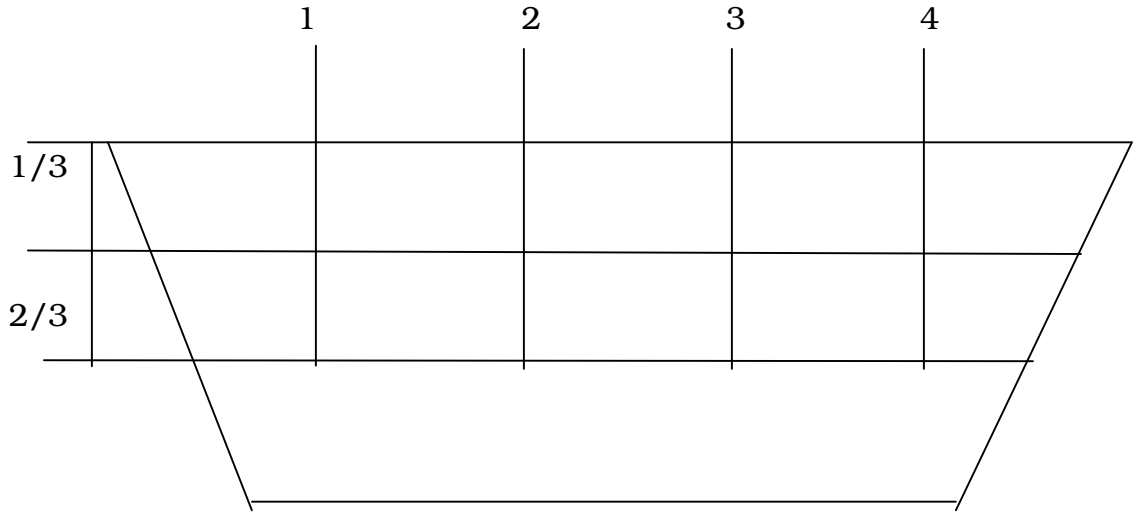


Fig-8.5.1

**A. Readings of Pitot Survey**

| **Reading No** | **Dia x** | **Location** | **dp mmwcl** | **$dp^{0.5}$** |
|---|---|---|---|---|
| 1 | 0.013 | | | |
| 2 | 0.039 | | | |
| 3 | 0.067 | | | |
| 4 | 0.097 | | | |
| 5 | 0.129 | | | |
| 6 | 0.165 | | | |
| 7 | 0.204 | | | |
| 8 | 0.25 | | | |
| 9 | 0.306 | | | |
| 10 | 0.388 | | | |
| 11 | 0.612 | | | |
| 12 | 0.694 | | | |
| 13 | 0.75 | | | |
| 14 | 0.796 | | | |
| 15 | 0.835 | | | |
| 16 | 0.871 | | | |
| 17 | 0.903 | | | |
| 18 | 0.933 | | | |
| 19 | 0.961 | | | |
| 20 | 0.987 | | | |
| | | | Average | |

**Format-8.5.1**

**B. Calculation of CW flow Measurement**

The formula for calculation of CW flow if dp mapping is done using a two port pitot is given below.

**CW flow $Q = dp^{0.5}$ (504.4883 x k x A) t/hr**

Where

Q = CW Flow in t/hr
dp = average dp measured in mm
k = Pitot coefficient
A = Area of duct in m2

**8.5.4.7.6 Fan Power**

Power consumption for the cooling Tower fans shall be measured at the MCC incomer for each individual fans.

**8.5.4.7.7 Wind Velocity**

Wind Velocity shall be measured by a rotating cup type anemometer.

**8.5.4.8 Calculation Tower Performance**

**Tower Capability in Percentage** = $\frac{\text{Adjusted Test Flow Rate}}{\text{Predicted Water Flow Rate}}$

**Adjusted Test Flow Rate** = Measured flow x $\left\{\frac{\text{Design KW of fans}}{\text{Test KW of Fans}}\right\}^{0.333}$

**Predicted Water Flow Rate** = Calculated from Manufacturer graphs and Actual test conditions i.e. WBT, Range and Cold water temperature.

**8.5.4.9 Steps for determining Predicted water Flow Rate**

i) Manufacturer provides design graphs of cold water temp vs. wet bulb temp for 90%, 100% & 110% flows and different cooling ranges (Fig 8.5.2, Fig 8.5.3, Fig 8.5.4)

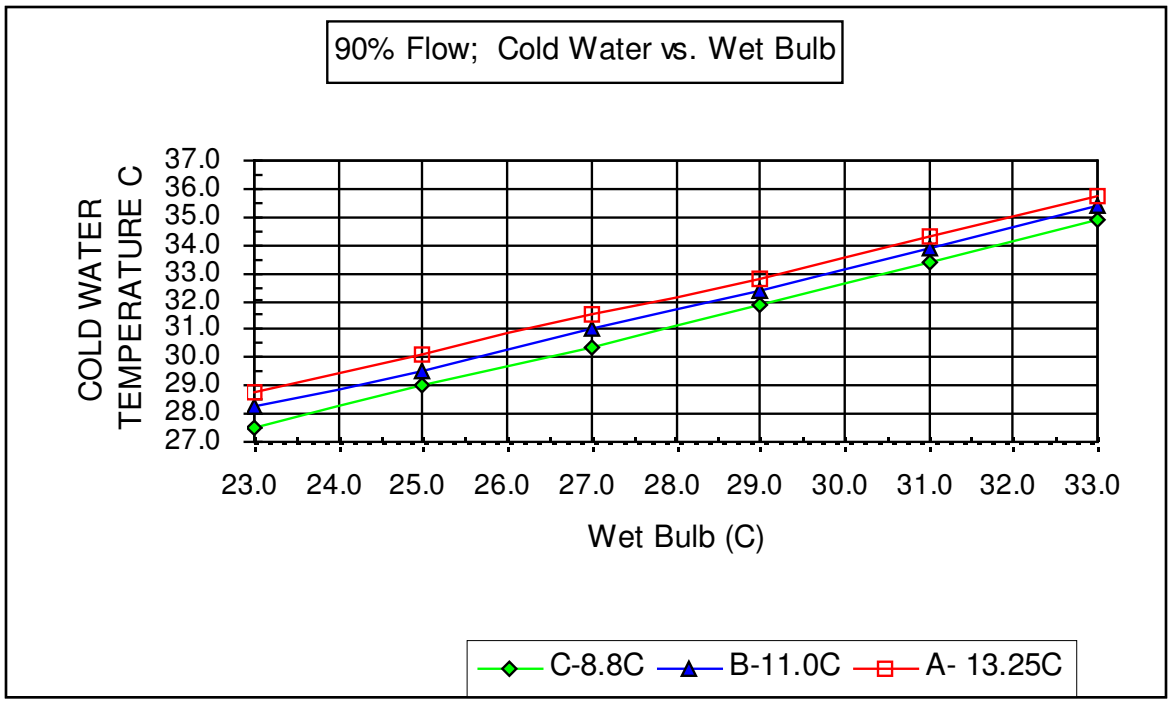


Fig- 8.5.2

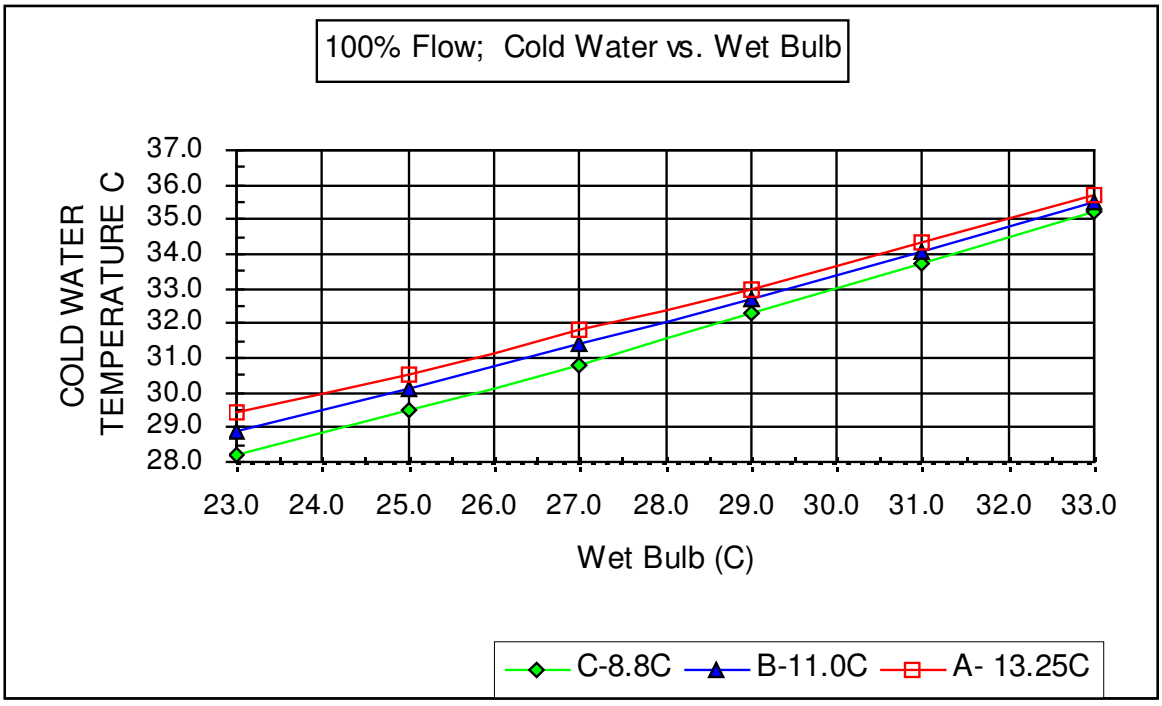


Fig-8.5.3

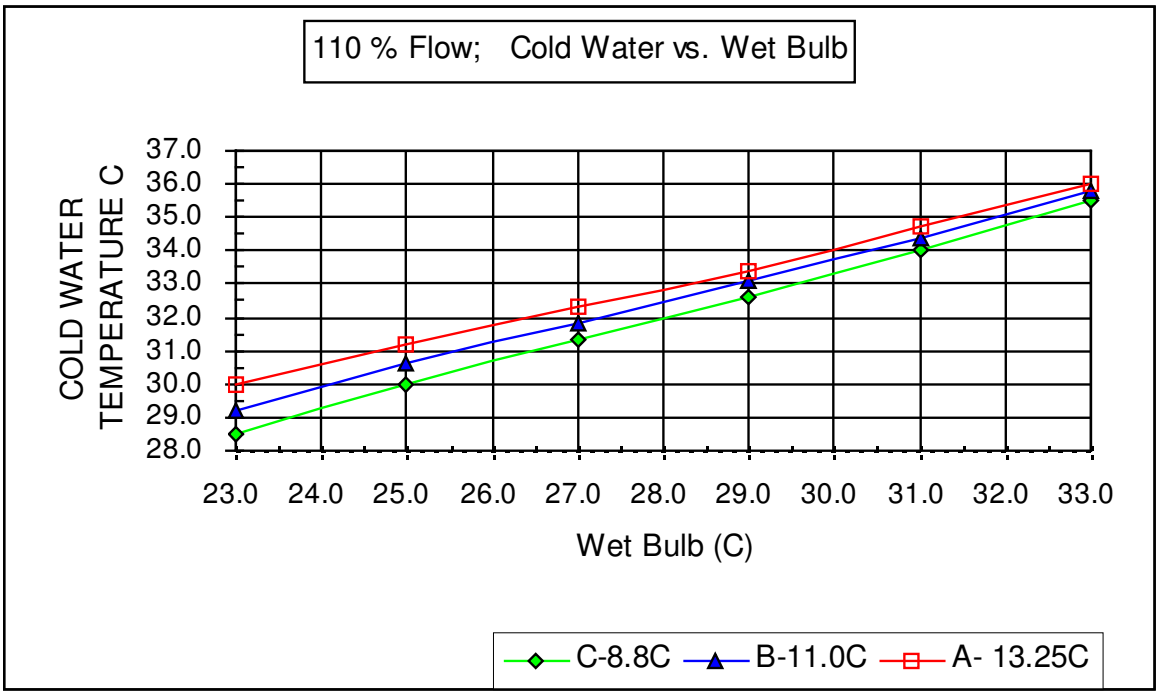


Fig-8.5.4

ii) Based on the actual test WBT, cold water temp is determined for different ranges and flows from the above curves

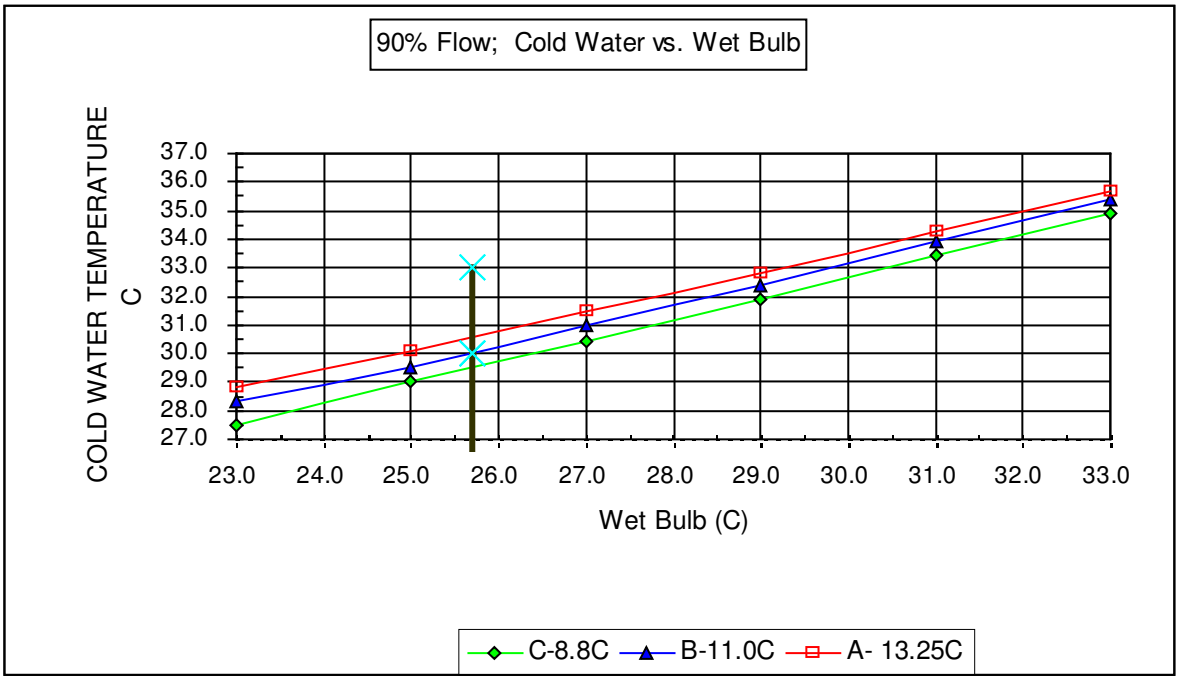


Fig-8.5.5

iii) Graph plotted with cold water temp vs. cooling range for 90%, 100% & 110% flows

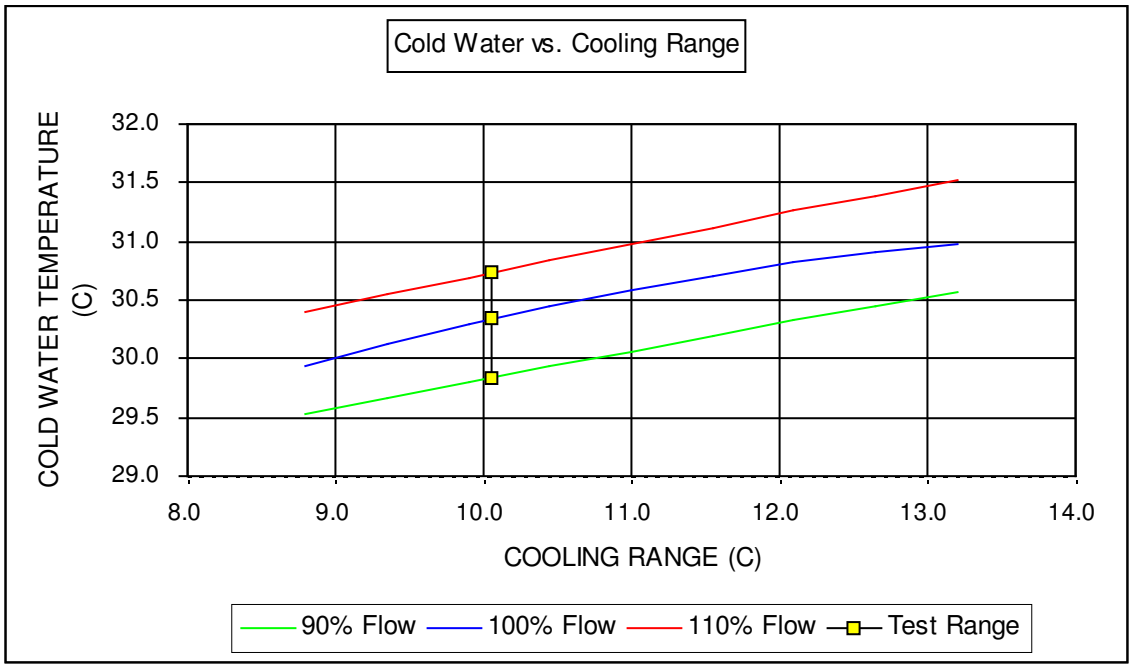


Fig-8.5.6

iv) From the above graph, based on actual test cooling range, cold water temp determined for 90%, 100%, 110% flows

v) Graph plotted with cold water temp vs. predicted flow

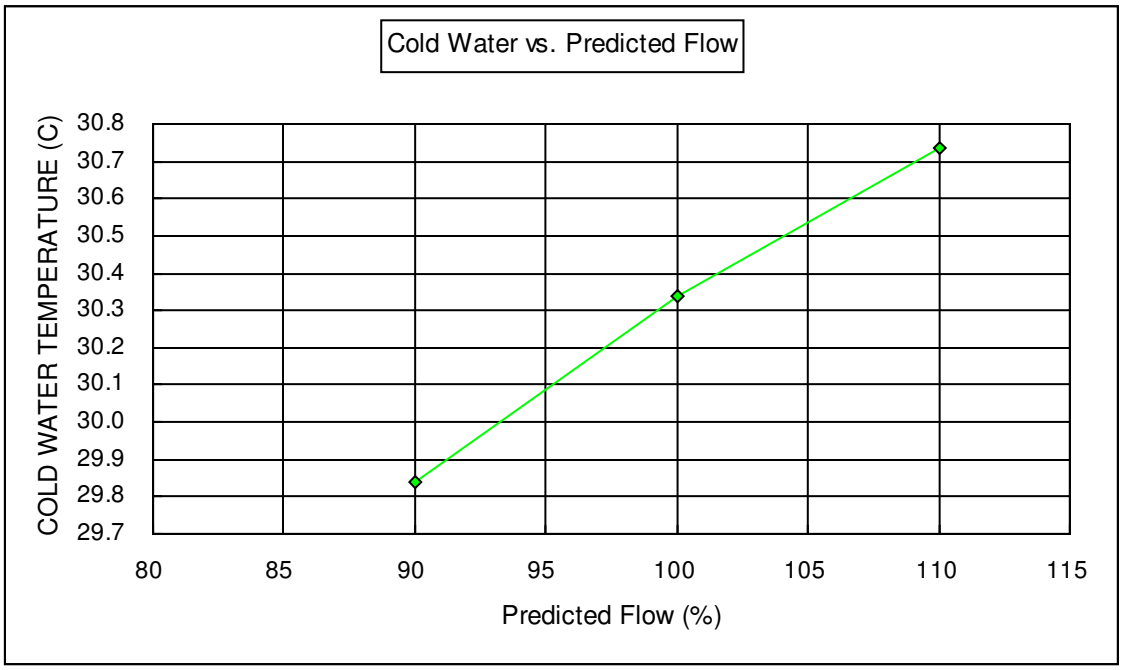


Fig-8.5.7

vi) From the above graph, based on actual test cold-water temp, predicted flow determined.

### 8.5.5 References

Cooling Tower Institute Acceptance Test Code for Water- Cooling Towers: CTI ATC - 105.

## Cooling Tower Performance Report

**Station** **Date**

| Parameters | Units | Design | Test | Test |
|---|---|---|---|---|
| **No of cells** | No | | | |
| **Water Flow Rate** | m3/hr | | | |
| **Hot Water Temperature** | ˚C | | | |
| **Cold Water Temperature** | ˚C | | | |
| **Wet Bulb Temperature** | ˚C | | | |
| **Fan Power** | ˚C | | | |
| **Range** | ˚C | | | |
| **Approach** | ˚C | | | |
| **Effectiveness** | % | | | |
| **Capability** | % | | | |

**Format-8.5.1**