# CLAYTON TECHNOLOGIES INDIA PVT. LTD.

# Performance Report of Induced Draft Cross Flow Cooling Tower
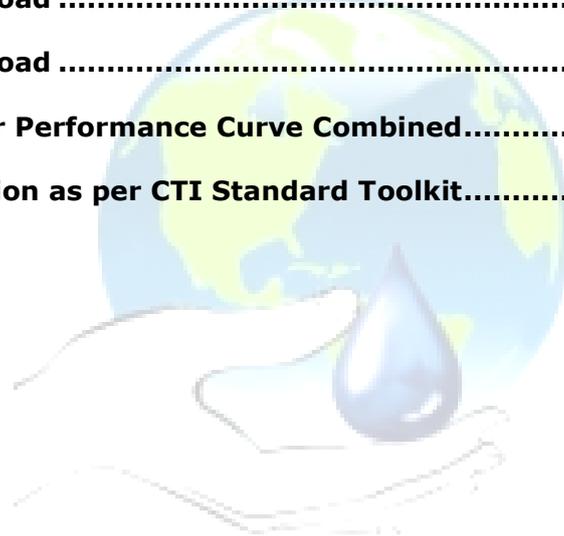
Purchase Order No MM / NCPL / 06 / KDP / 610 / 42273 date. 28-6-2006.

Sanjay Goyal

## CLAYTON TECHNOLOGIES INDIA PVT. LTD.

## Table of Contents

## 1. Preface

The evaluation of Field Test Data is consisting of interpolation techniques to enable a comparison of actual capability from the test data and predicted capability from the performance curves.

**Two equations are used for this purpose.**

Adjusted Test Water Flow ($M^3$ / HR) = Test Water Flow x $\sqrt[3]{}$ (DESIGN FAN POWER / TEST FAN POWER) → 1

% Capability = (ADJ. TEST WATER FLOW / PREDICTED WATER FLOW) x 100 → 2

Equation (1) is used to predict the amount of water the tower could cool, at test temperatures, if the fan drivers were loaded to design power, and is based on the following assumptions:

- The Water Flow Capacity of a cooling tower is directly proportional to the Air Flow.
- The Air Flow is proportional to the Cube Root of the Power delivered to the fan.

Actually the water flow capacity of a cooling tower deviates from the straight line relationship with air flow, due to change in drop size, interfacial area, and distribution, but the error is small for small changes in air flow. Also, air flow deviates from the cube root relationship with power, due to the fact that a change in water loading is involve, and to the fact that the fan efficiency does not remain exactly constant as air and water flows, and hence static pressure are changed. For these reasons it is desirable that water circulation rate and fan power be held reasonably close to design during a test. For water circulation rate, the limits of +/- 10% specified in CTI – ATP – 105 are recommended. Although no limits on fan power are specified in **CTI ATP – 105**, +/- 20% (with proper precaution to avoid over loading of mechanical equipment) is recommended.

In summary, the closer water circulation rate and fan power are to design, the less will be the error due to the adjustment of test water circulation rate by means of Equation (1). If the limitations recommended above are observed, this error will generally be within the limits of testing accuracy.

Equation (2) is used for the final quantitative comparison of actual and predicted capacity.

## 2. Thermal Performance Testing

## 2.1 CROSS FLOW COOLING TOWER 'A' DATA

| S .No. | Design Factor | Design Data | Av. Test Data |
|--------|---------------|-------------|---------------|
| 1. | Water Flow Rate ($M^3$/ HR) | 1000 | 876.3 |
| 2. | Hot Water Temperature (° C) | 38.5 | 33.5 |
| 3. | Cold Water Temperature (° C) | 32.5 | 26 |
| 4. | Wet Bulb Temperature (° C) | 28.3 | 19.75 |
| 5. | Dry Bulb Temperature (° C) | 35 | 26.75 |
| 6. | Range (° C) | 6 | 7.5 |
| 7. | Approach (° C) | 4.2 | 6.25 |
| 8. | Fan Power ( kW ) | 19 | 20.33 |

From Equation (1):

**Adj. Test Water Flow Rate**        = 876.3 x Cube Root of (19 / 20.33)

= 856.76 $M^3$/ HR

The determination of Predicted Water Flow Rate from the Performance Curve No. 1, 2 & 3 (Enclosed) is accomplished in the following manner.

Cold Water Temperatures at Test Wet Bulb Temperature of 19.75 $^0$C are read from the performance curve no. 1, 2 & 3 and are as under.

## 2.2 Cold Water Temperature @ Test WBT 19.75 $^0$C

**Predicted Cold Water Temperature** ($^0$C)

| S. No. | Cooling Range ( $^0$C) | 900 $M^3$/ HR | 1000 $M^3$/ HR | 1100 $M^3$/ HR |
|--------|------------------------|---------------|----------------|----------------|
| 1. | 4.8 | 25.2 | 25.6 | 26.4 |
| 2. | 6.0 | 26.1 | 26.5 | 27.4 |
| 3. | 7.2 | 26.8 | 27.5 | 28.4 |

The above data are used to produce the curve 4 and Cold Water Temperatures at the Test Range of 7.5 $^0$C are then read from the curve 4 and are as under.

## 2.3 COLD WATER TEMPERATURES @ TEST WBT 19.75 $^0$C & RANGE 7.5 $^0$C

| S No. | Water Flow Rate M$^3$/ HR | Cold Water Temperature $^0$C |
|---|---|---|
| 1. | 900 | 26.95 |
| 2. | 1000 | 27.76 |
| 3. | 1100 | 28.65 |

Finally the above data are plotted to produce the Curve No. 5 (enclosed)

Predicted Water Flow Rate is found from the curve no. 4 and is 785 M$^3$/ HR. at the test cold water temperature of 26 $^0$C

**Hence the % capability of the cooling tower is calculated from the Equation (2)**

% CAPABILITY      = (ADJ. TEST WATER FLOW / PREDICTED WATER FLOW) x 100
                  = (856.76 / 785) x 100
                  = 109.14 %

From the above report, it is clear that the capability of tower is in the acceptable range.
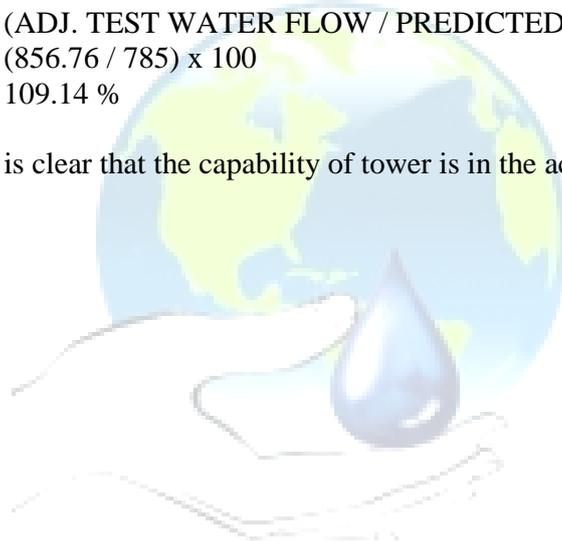
## 3.0 Curves

### 3.1 At 90% water load
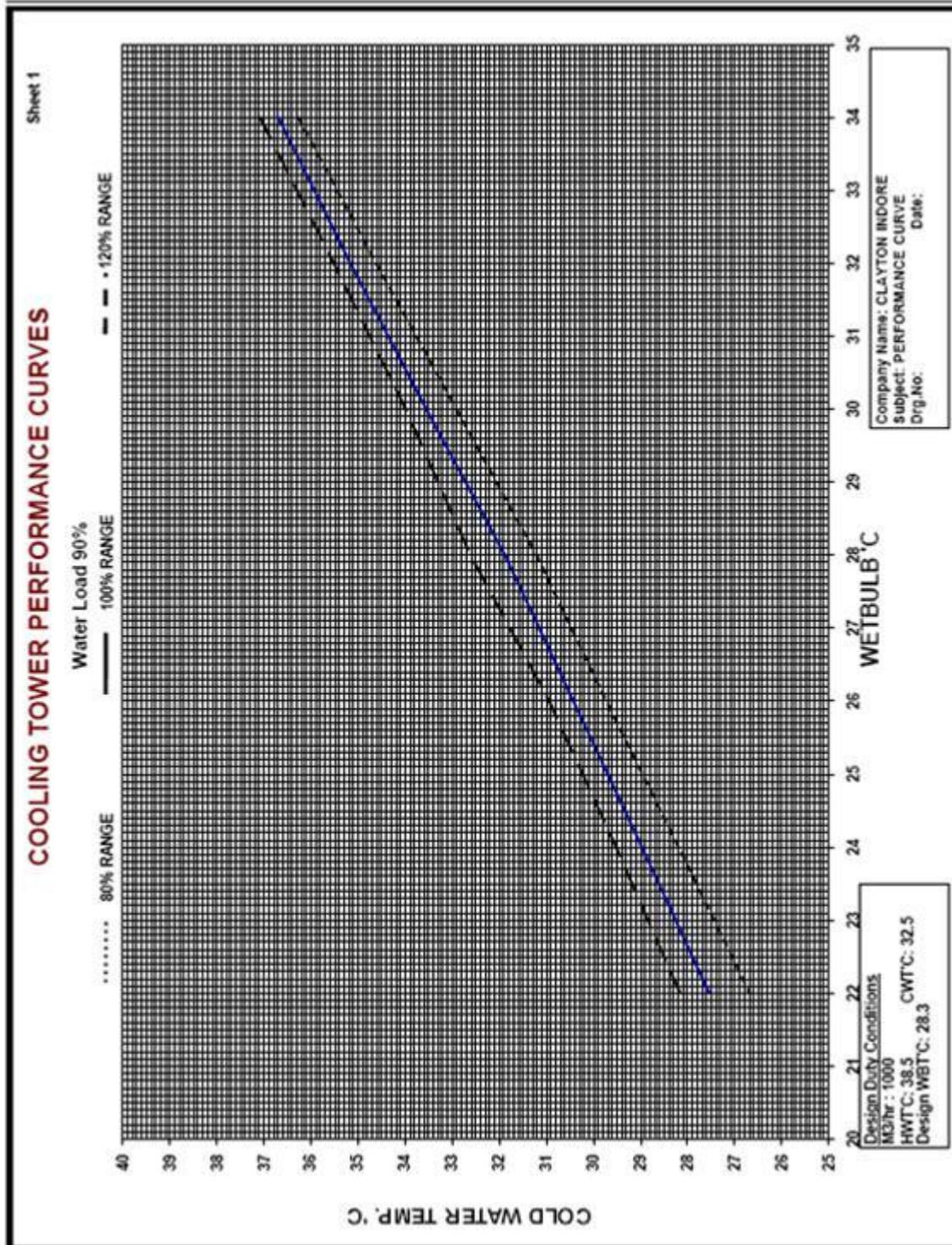
## 3.2 At 100% water load

## 3.3 At 110% water load



**COOLING TOWER PERFORMANCE CURVES**

Water Load 110%

Sheet 3

........ 80% RANGE ——— 100% RANGE – – +120% RANGE

COLD WATER TEMP. °C

WETBULB °C

Design Duty Conditions
M3/hr : 1000
HWT°C: 38.5    CWT°C: 32.5
Design WBT°C: 28.3

Company Name : CLAYTON INDORE
Subject: PERFORMANCE CURVE
Drg.No:    Date:
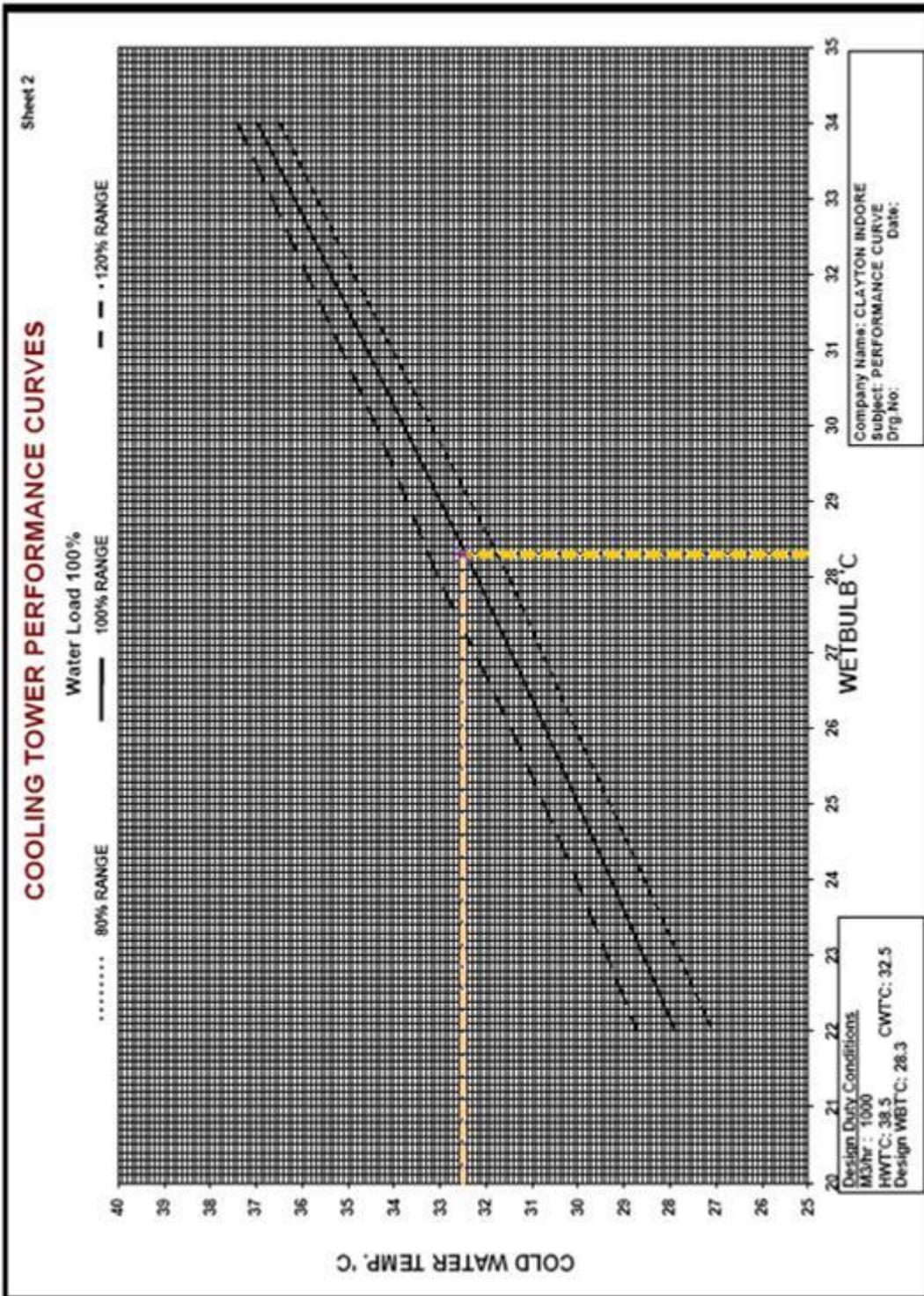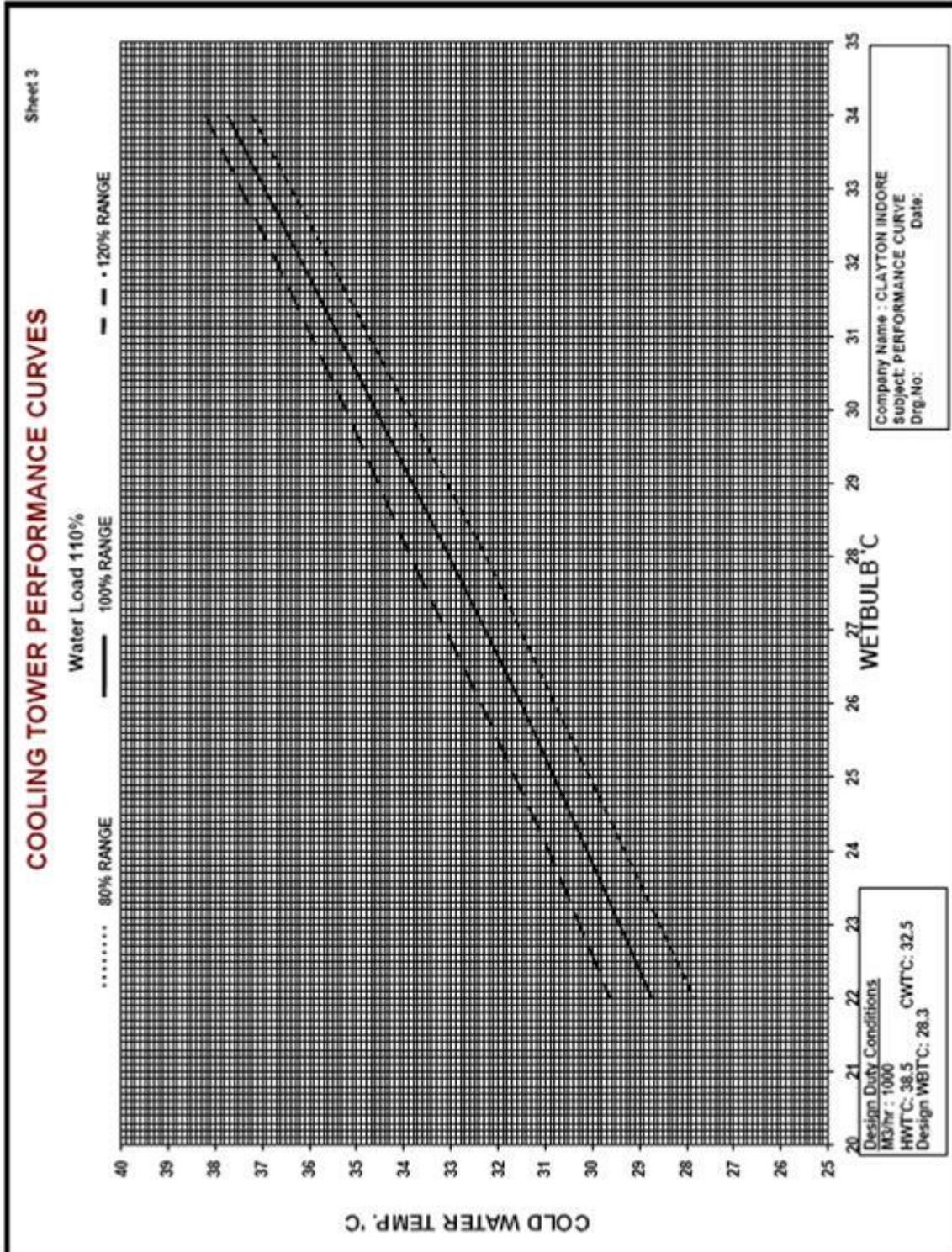
## 3.4 At Cooling Tower Performance Curve Combined



| wbt °C | 0.8*R water load | R 90%-CWT°C | 1.2*R | 0.8*R water load | R 100%-CWT°C | 1.2*R | 0.8*R water load | R 110%-CWT°C | 1.2*R |
|---|---|---|---|---|---|---|---|---|---|
| 34 | 36.27 | 36.7 | 37.09 | 36.48 | 36.97 | 37.41 | 37.23 | 37.74 | 38.21 |
| 32 | 34.62 | 35.17 | 35.52 | 34.88 | 35.37 | 35.89 | 35.55 | 36.16 | 36.7 |
| 30 | 32.91 | 33.55 | 33.99 | 33.19 | 33.79 | 34.39 | 33.93 | 34.6 | 35.23 |
| 28 | 31.21 | 31.88 | 32.61 | 31.5 | 32.2 | 33.04 | 32.25 | 33.04 | 33.86 |
| 26 | 29.73 | 30.43 | 30.94 | 30.06 | 30.71 | 31.45 | 30.8 | 31.51 | 32.36 |
| 24 | 28.19 | 28.97 | 29.52 | 28.55 | 29.28 | 30.03 | 29.31 | 30.11 | 30.92 |
| 22 | 26.68 | 27.54 | 28.16 | 27.07 | 27.88 | 28.71 | 27.84 | 28.74 | 29.63 |

Input Design WBT & CWTs only in the cells given below.

WBTC= 28.3    10    WBTC= 28.3 CWTC=    28.3 CWTC= 32.5

WBTC= 28.3 CWTC= 32.5    10 CWTC= 32.5

COOLING TOWER PERFORMANCE CURVES

COLD WATER TEMP. °C

WETBULB °C

Cooling Tower Performance Curve

CWT V/S RANGE AT TEST WBT 19.75°C

COOLING TOWER PERFORMANCE CURVES

COLD WATER TEMPERATURE (°C)

WATER FLOW RATE (Cum/Hr.)

Design Duty Conditions
M3/hr : 1000 m3/hr
HWT°C : 38.5     CWT°C : 32.5
Design WBT°C : 28.3

Company Name : N.C.P.L. BHARUCH
Subject : Performance Curve
Drg. No.          Date :

# Clayton Technologies India (P) Ltd.

## Tower Performance Report

Cooling Tower A 12/22/06

Owner: Narmada Chematur Petrochemicals Ltd.
Project: Cooling Tower A
Location: Bharuch
Manufacturer: Paharpur
Tower Type: Induced Draft

### Cooling Tower Design and Test Data

| Parameters | Design | Test |
|---|---|---|
| Water Flow Rate | 277.7 l/s | 243.4 l/s |
| Hot Water Temp. | 38.50 °C | 33.50 °C |
| Cold Water Temp. | 32.50 °C | 26.00 °C |
| Wet Bulb Temp. | 28.30 °C | 19.75 °C |
| Dry Bulb Temp. | 35.00 °C | 26.75 °C |
| Fan Driver Power | 19.00 kW | 20.33 kW |
| Barometric Pressure | 101.325 kPa | 101.325 kPa |
| Liquid to Gas Ratio | 1.360 | 1.134 |

### Cold Water Temperatures vs. Range
At 19.75 °C Test Wet Bulb

| Range | 250.0 l/s | 277.7 l/s | 305.5 l/s |
|---|---|---|---|
| 4.80 °C | 24.98 °C | 25.41 °C | 26.19 °C |
| 6.00 °C | 25.93 °C | 26.31 °C | 27.20 °C |
| 7.20 °C | 26.63 °C | 27.23 °C | 28.18 °C |

### Cold Water Temperature vs. Water Flow
At 19.75 °C Test Wet Bulb and 7.50 °C Test Range

| 250.0 l/s | 277.7 l/s | 305.5 l/s |
|---|---|---|
| 26.80 °C | 27.45 °C | 28.42 °C |

### Exit Air Properties

|  | Wet Bulb Temp | Density | Sp. Vol. | Enthalpy |
|---|---|---|---|---|
| Design | 34.36 | 1.12451 | 0.9208 | 125.2839 |
| Test | 28.44 | 1.15337 | 0.8886 | 92.1250 |

### Test Results
* Indicates predicted flow is extrapolated

| Adjusted Flow | Predicted Flow | CWT Deviation | Tower Capability |
|---|---|---|---|
| 240.0 l/s | 215.7 l/s * | -313.90 °C | 111.2% |

This test result is only certified by CTI if the test data was collected by a CTI Licensed Testing Agency. See www.cti.org for an agency list.

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## 3.5 Thermal Evaluation as per CTI Standard Toolkit