Ozone Water System

The Non-Residual Chemical Condenser Water Treatment

Manufactured By

Thai Energy Conservation Co., Ltd

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Problems in Water-Cooled System

1. Why Condenser approach temperature keep on increasing?
2. Why we need to clean the condenser tube very often?
3. Why we have to add the chemicals in cooling system?
4. Why we must bleed off plenty of water?
5. Why the pipe clogged ?
6. Why condenser pump require more energy?
7. Why we need to clean the cooling tower too often?
8. Why employees who have direct contact with the cooling tower caught with respiratory disease?

Why do we need to pay more?

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What are the problems in water-cooled system?

1. Scales
2. Bio-Films
3. Corrosion
4. Infection

Problems in Water-Cooled System

Scales

- Reduce the efficiency of heat transfer in condenser

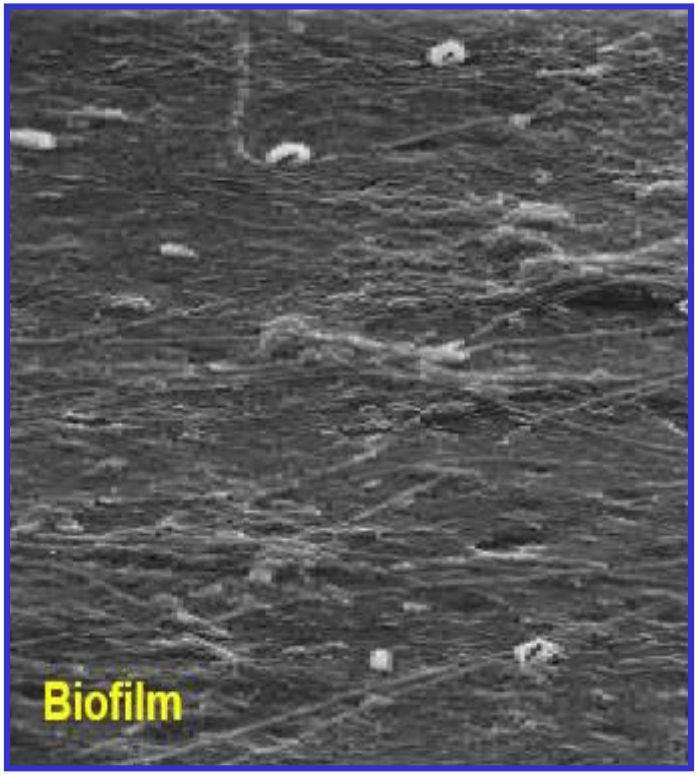
-Increase maintenance cost for cleaning condenser and cooling tower

-Frequently chemical clean leads to condenser tube damages

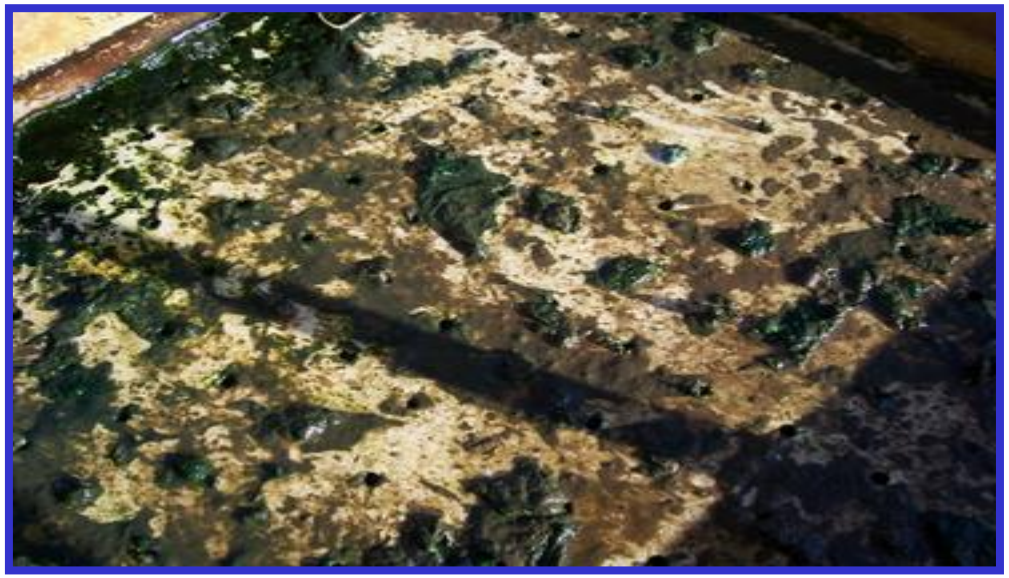
Causes of scale problem

Scale Development

- Bio-film form when bacteria adhere onto surfaces of condenser pipes and acts as an adherent for mineral scale deposition.



Problems in Water-Cooled System



Slime

- Reduce heat transfer efficiency
- Clogging pipe-lines and strainer
- Increase maintenance cost for cleaning cooling tower

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Problems in Water-Cooled System

Corrosive

- Damage to pipe-line and equipments
- Lead to clog problem in pipe line

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Problems in Water-Cooled System

Infection

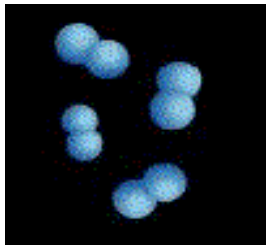
- Legionnaires' disease is a serious lung disease (pneumonia) and it can be caught from piped water, circulating water droplets in air-conditioning and cooling systems, cooling towers and evaporative condensers.

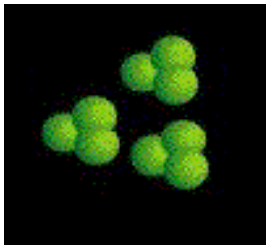
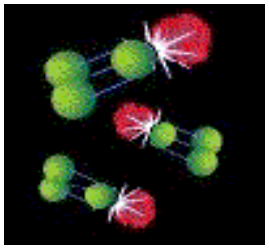
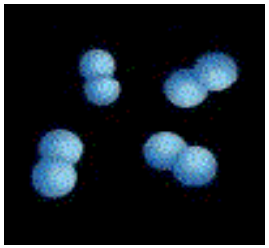
Legionellosis

(Bacteria Legionella Pneumophila)

What is Ozone?

Ozone (O_3) is an unstable gas formed by combining three atoms of oxygen. Ozone is produced when oxygen module (O_2) are split into two oxygen atom combines with remaining oxygen molecule forming ozone.



•Oxygen (O_2) + Energy = Ozone (O_3) ➡Oxidation ➡Oxygen (O_2)

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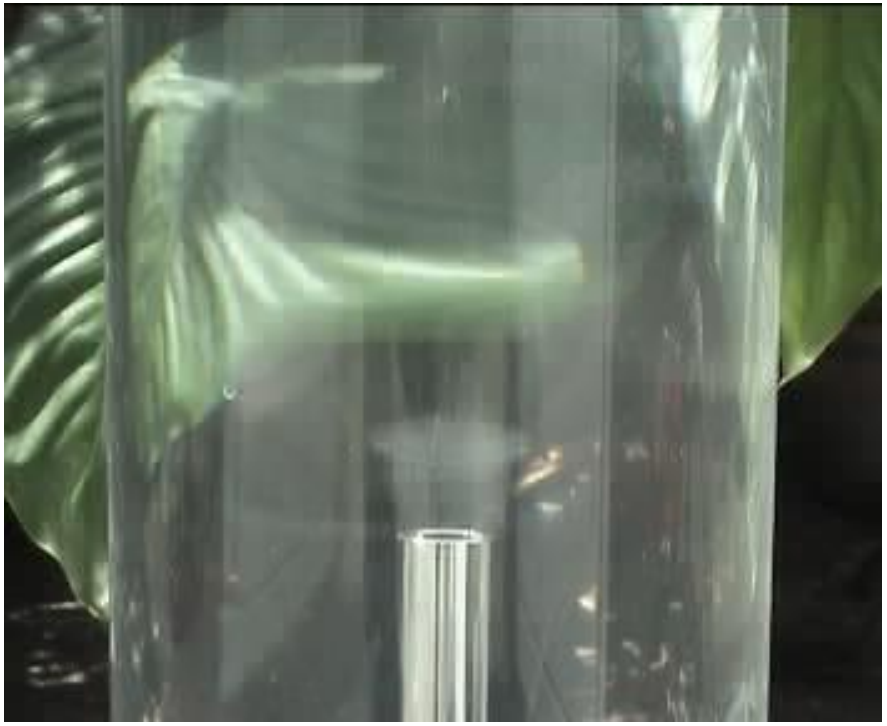
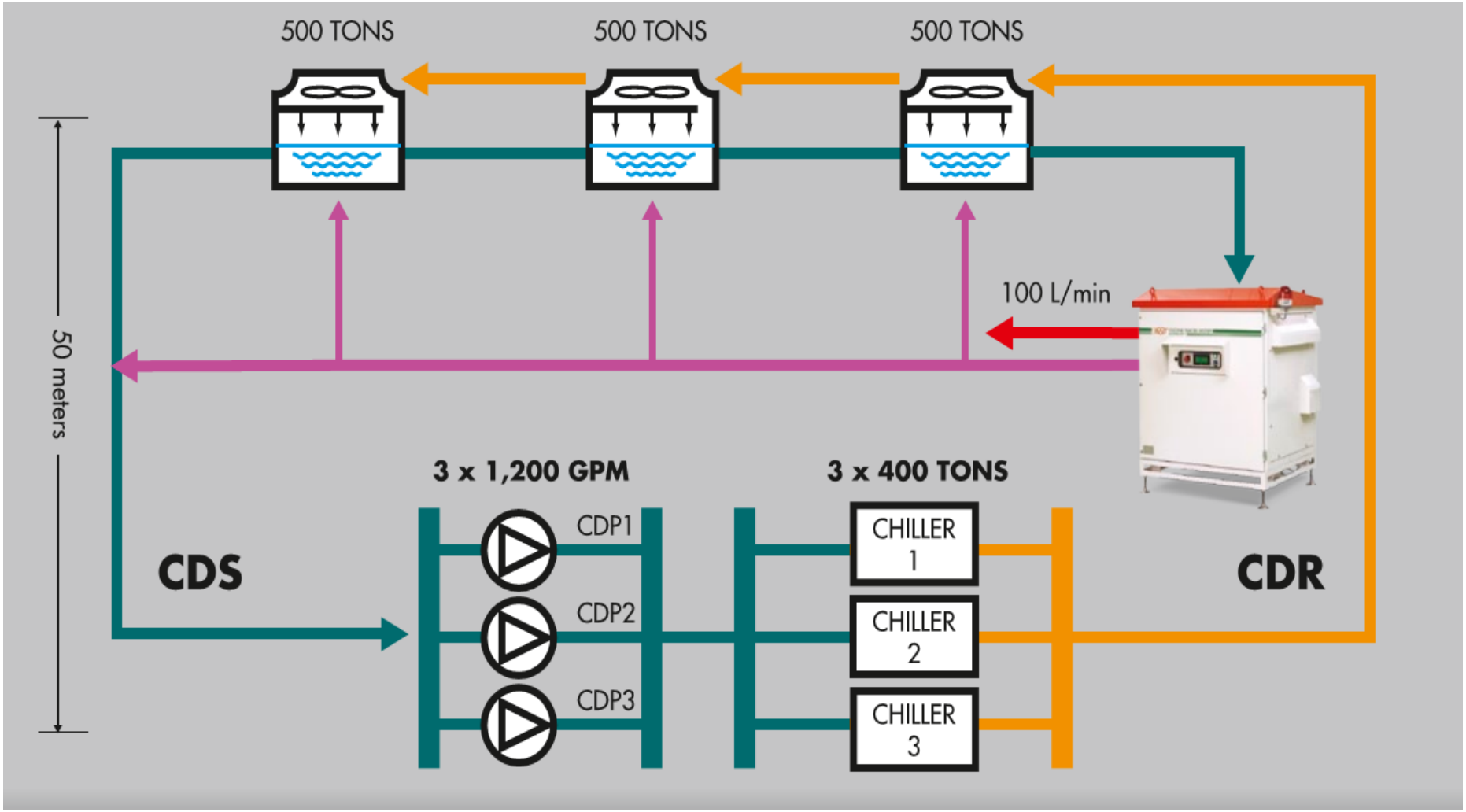
High Efficiency Ozone Water Mixing System



Installation Diagram

Animation



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Quick selection ozone model versus chiller size

Model	Maximum Total Chiller Size in Ton Refrigeration
OZG 10 N	400
OZG 25 N	800
OZG 50 N	1500
OZG 70 N	2000
OZG 100 S	2500

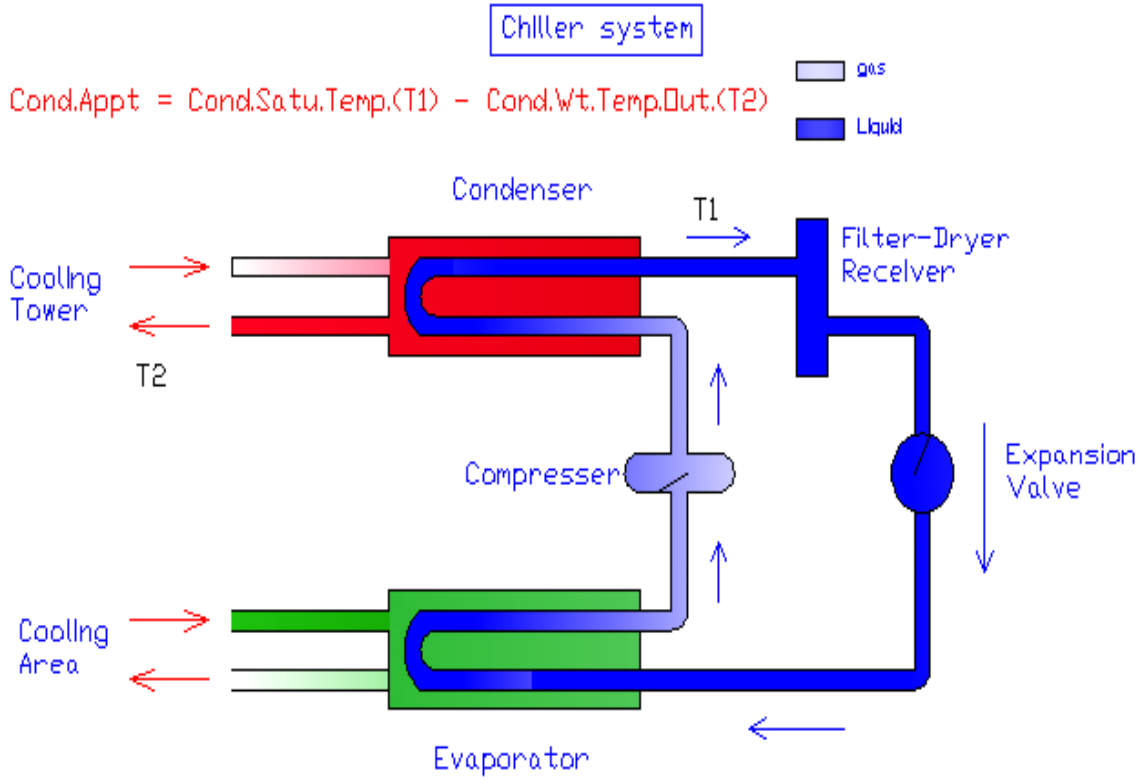
Distance between cooling tower and condenser shall not be more than 50 meters.

Performance indicator

- Condenser Approach Temperature can be used as the performance indicator.

Increasing condenser approach temperature indicate that heat transfer efficiency is decreasing.

- Accordingly, Energy saving can be achieved when Condenser Approach Temperature is running stable below its specification (Depend on Air Condition manufacturer) and help reduce water for blowing down from cooling tower.



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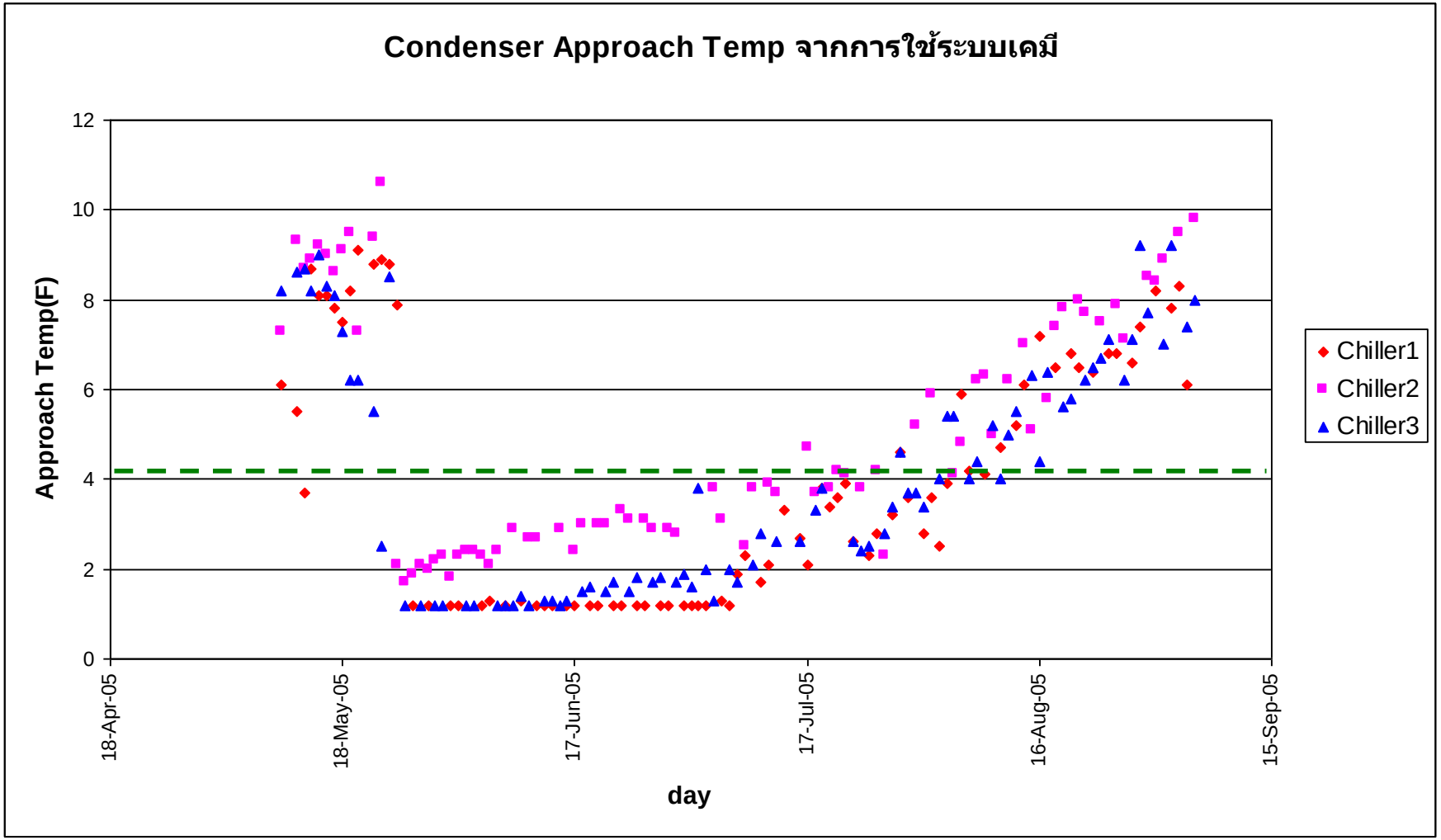
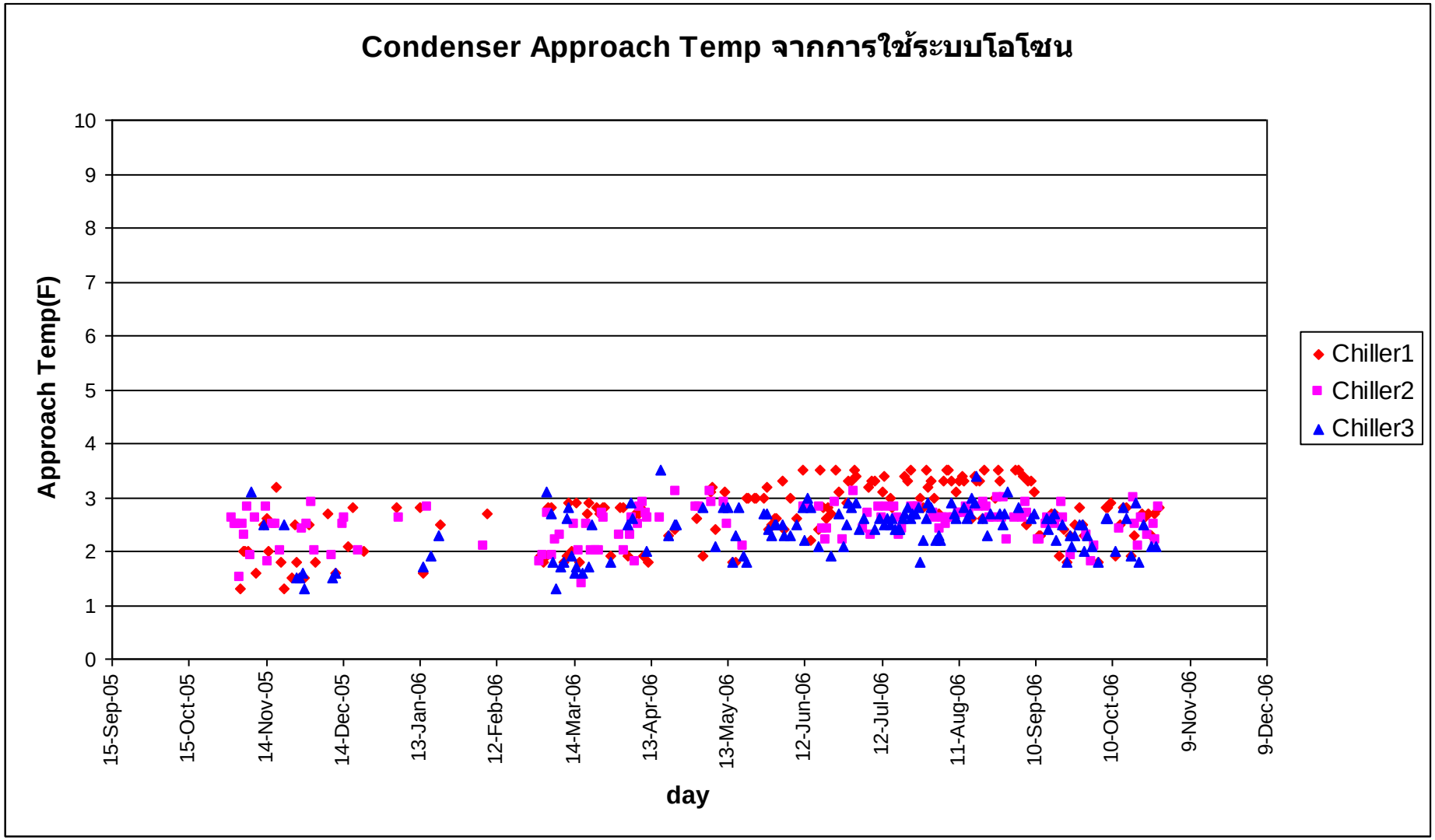
The relationship between Condenser Approach Temperature and the performance of Chiller.

- An increasing of every 1°F in condenser approach temperature would affect energy consumption (kW/Ton) of approximately 1.5% suggest that the performance of chiller decrease by 1.5%
- Optimum heat transfer when Condenser Approach Temperature is between 0-2 °F

Condenser Approach Temperature during use Chemical in Cooling Tower



Condenser Approach Temperature during use Ozone in Cooling Tower



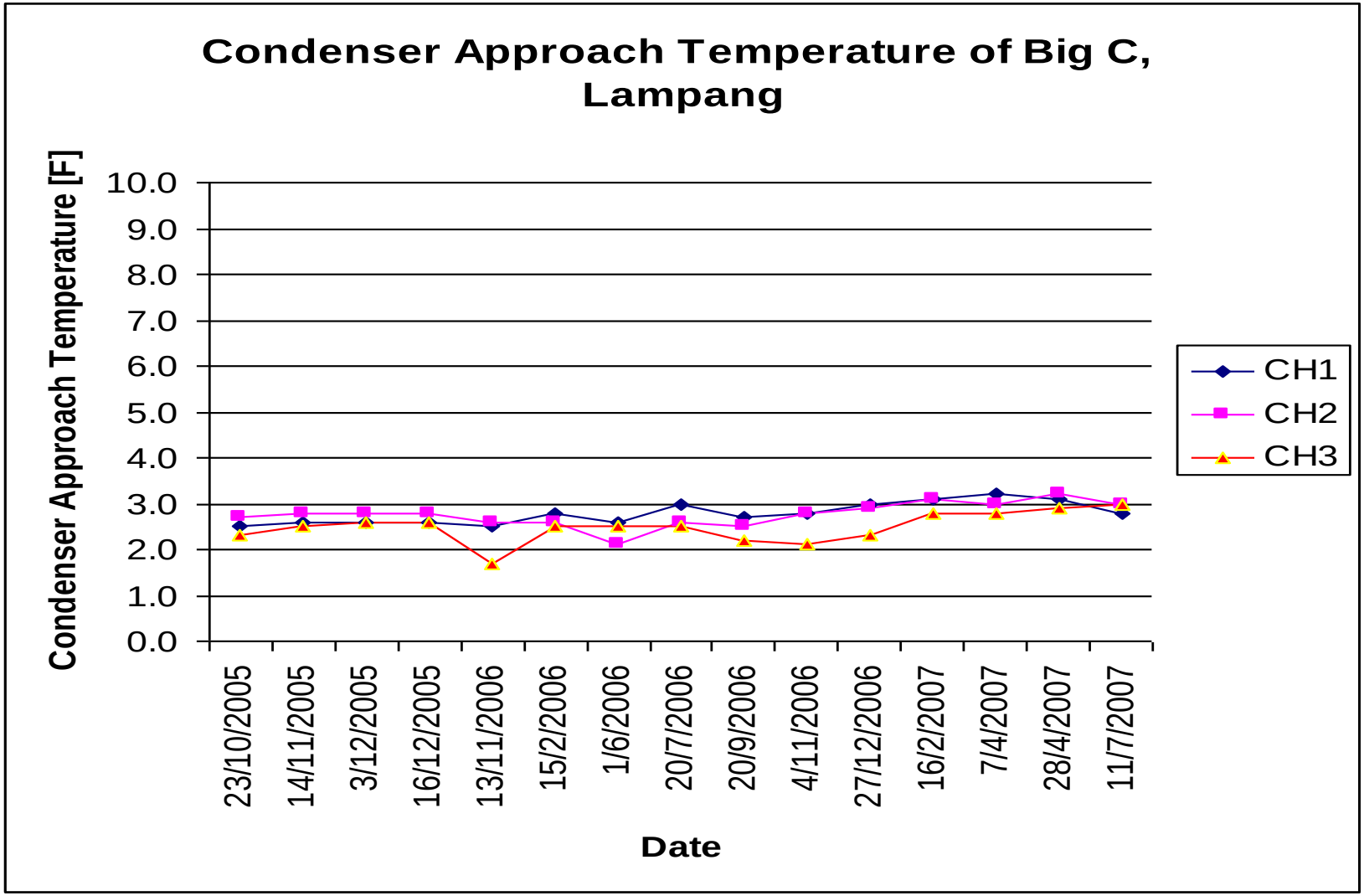
Condenser Tube (comparing between ozone and chemical)

Condenser tubes after cleaned with the brush and acid

After used with Ozone for 12 months

After used with Chemical for 6 months

Shown two years Cond. App. Temp. Records



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How can ozone save the energy in HVAC system?

Using Ozone water system in HVAC system to prevent scale formation and control of algae growth which causes lower heat transfer efficiency

The treatment cost comparison between Ozone and Chemicals are determined as follow:

1. Chiller's electricity consumption
2. Make-up water cost
3. Chemical treatment cost
4. Condenser cleaning cost
5. Water treatment's electricity consumption

Input Data for calculation

Example: **OZONE WATER SYSTEM FOR WATER-COOLED CHILLER**

Cooling capacity

Water Cooled Chiller 500 TONS x 4 Sets (Max. operating total 3 Sets)

Cooling Tower 500 TONS x 4 Sets (Max. Operating total 3 Set)

Input data on electricity, water for energy saving calculation

1) Chiller performance (kW/ TR) calculate at 0.65 kW/TON
2) Chiller Load Factor = 80%
3) Operate 24 Hour per day and 365 days per year
4) Electricity Tariff 3 Baht per unit
5) Water Tariff 10 Baht per unit
6) Soft water cost 3 Baht per unit
7) Condenser Pump Flow = 3,600 GPM = 817.6 m3/hr.
8) Chemicals Expenses = 210,000 Baht per year (Estimated)
9) Condenser Cleaning = 10,000 Baht per chiller

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Energy Consumption of Chiller System

1. Energy Consumption

Energy Consumed by Chiller System

$$= \quad 1{,}500 \times 0.65 \times 0.8 \times (24 \times 365) \times 3$$

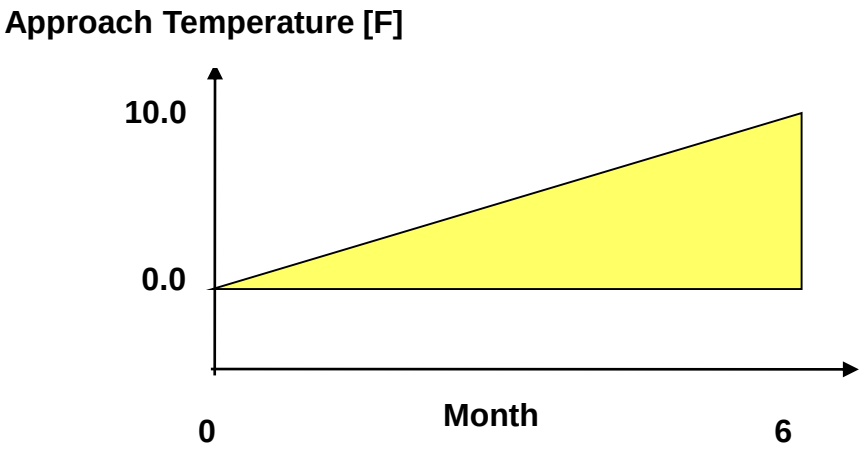
$$= \quad \mathbf{20{,}498{,}400} \text{ Baht/Year}$$

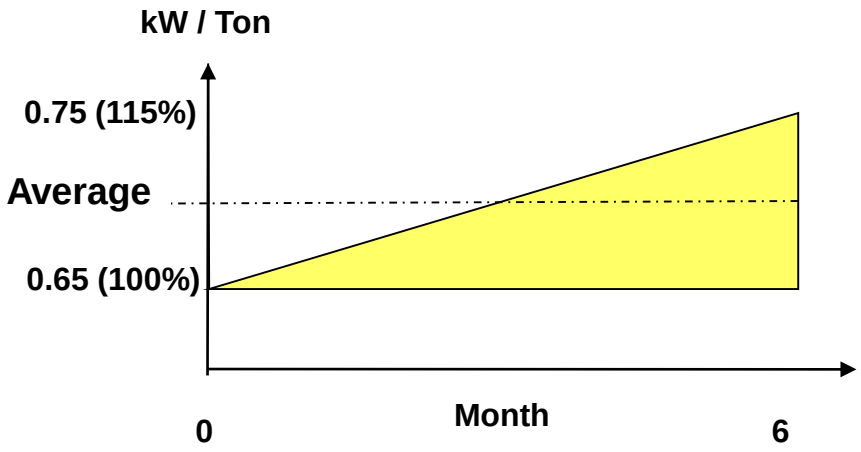
In fact, the efficiency of the water-cooled chiller will steadily declines when the system gets older due to scale accumulation on condenser tube.

Energy Consumption of Chiller System

1. Energy Consumption(Cont'd)

1°F increase of condenser approach temperature can increase refrigeration compressor power usage by approximately 1.5% (Usually should not exceed 10 °F)





Therefore, the average energy loss for 1 period start from the date of de-scaling until next de-scaling the energy loss can be increase from 0% to 15%

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Energy Consumption of Chiller System

1. Energy Consumption(Cont'd)

Considering the average energy loss for 1 period of operation (6 Months) is approximately 5-10% of the total energy consumption at fully load factor, if the average condenser approach temperature increasing is approximately 2.5^{o}F then the electricity consumption increase approximately 2.5 x 0.015 = 0.0375 Times

Therefore, the average energy loss per year by considering the minimum rate of 3.75%

= 20,498,400 x 0.037

= 768,690 Baht/Year

Therefore, the electricity charges during chemicals treatment

= 20,498,400 + 768,690

= 21,267,090 Baht/Year

Therefore, the electricity charges during ozone treatment

= 20,498,400 Baht/Year

Make-up water

2. Make-up water

2.1 Bleed off

As evaporation continues, the minerals and solids are left behind in the recirculating water making water becomes more and more concentrated. To prevent excessive concentration some of the circulating water must be removed from the system.

Chemical Treatment The amount of bleed-off are about 0.5% of the circulating rate

Bleed-off during chemical treatment = Circulating rate x 0.5% x CT operation period x Tariff (Tap Water + Soft water)

= 817.6 x 0.005 x (24 x 365) x (10+3)

= **465,541.44 Baht / Year**

Ozone Treatment The amount of bleed-off are about 0.25% of the circulating rate

Bleed-off during ozone treatment = Circulating rate x 0.25% x CT operation period x Tariff (Tap Water)

= 817.6 x 0.0025 x (24 x 365) x (10)

= **179,054.40 Baht / Year**

Make-up water

2. Make-up water (Cont'd)

2.2 Evaporation

The rate of evaporation is about 1.0 % of the rate of flow of the recirculating water passing through the Cooling tower

Evaporation during chemical treatment = Circulating rate x 1.0% x CT operation period x Tariff (Tap Water + Soft water)

= 817.6 x 0.01 x (24 x 365) x (10+3)

= **931,082.88 Baht / Year**

Evaporation during ozone treatment = Circulating rate x 1.0% x CT operation period x Tariff (Tap Water)

= 817.6 x 0.01 x (24 x 365) x (10)

= **716,217.60 Baht / Year**

Make-up water

2. Make-up water (Cont'd)

Make up water during chemical treatment = Bleed off + Evaporation

= 465,541 + 931,082

= **1,396,623 Baht / Year**

Make up water during ozone treatment = Bleed off + Evaporation

= 179,054 + 716,217

= **895,271 Baht / Year**

Chemicals cost and Condenser cleaning

3. Chemicals Cost

Chemicals Cost = Chemical Expenses per month x 12

= 210,000 Baht/Year

(Ozone treatment system uses no chemicals)

4. Condenser Cleaning

Chemicals Treatment system = Times per year x Amount of Condenser x Cleaning cost

= 2 Times x 4 Units x 10,000 Baht

= 80,000 Baht/Year

(No condenser cleaning routine during use ozone treatment system)

Energy Consumption

5. Energy Consumption of treatment system

Chemical Treatment: Chemicals feed pump = 1 kW

= **1 kW x Operation Period x Electricity charges**

= 1 x (14 x 365) x 3

= **15,330 Baht/Year** (Not calculated yet because it has not been installed)

Ozone Treatment: Total power consumption = 7.6 kW

= **7.6 kW x Operation Period x Electricity charges**

= 7.6 x (23 x 365) x 3

= **191,406 Baht/Year**

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Estimated Values for Guarantee Saving

Items	Chemicals (THB/Yr)	Ozone (THB/Yr)
Electricity consumption of chiller	21,267,090	20,498,400
Make up water cost	1,396,623	895,271
Chemicals Treatment cost	210,000	0
Condenser Cleaning cost	80,000	0
Electricity consumption of ozone system	0	191,406
Total Expenses	22,953,713	21,585,077
Total Saving		1,368,636

Estimated Payback Period

Electricity Saving after ozone treatment began

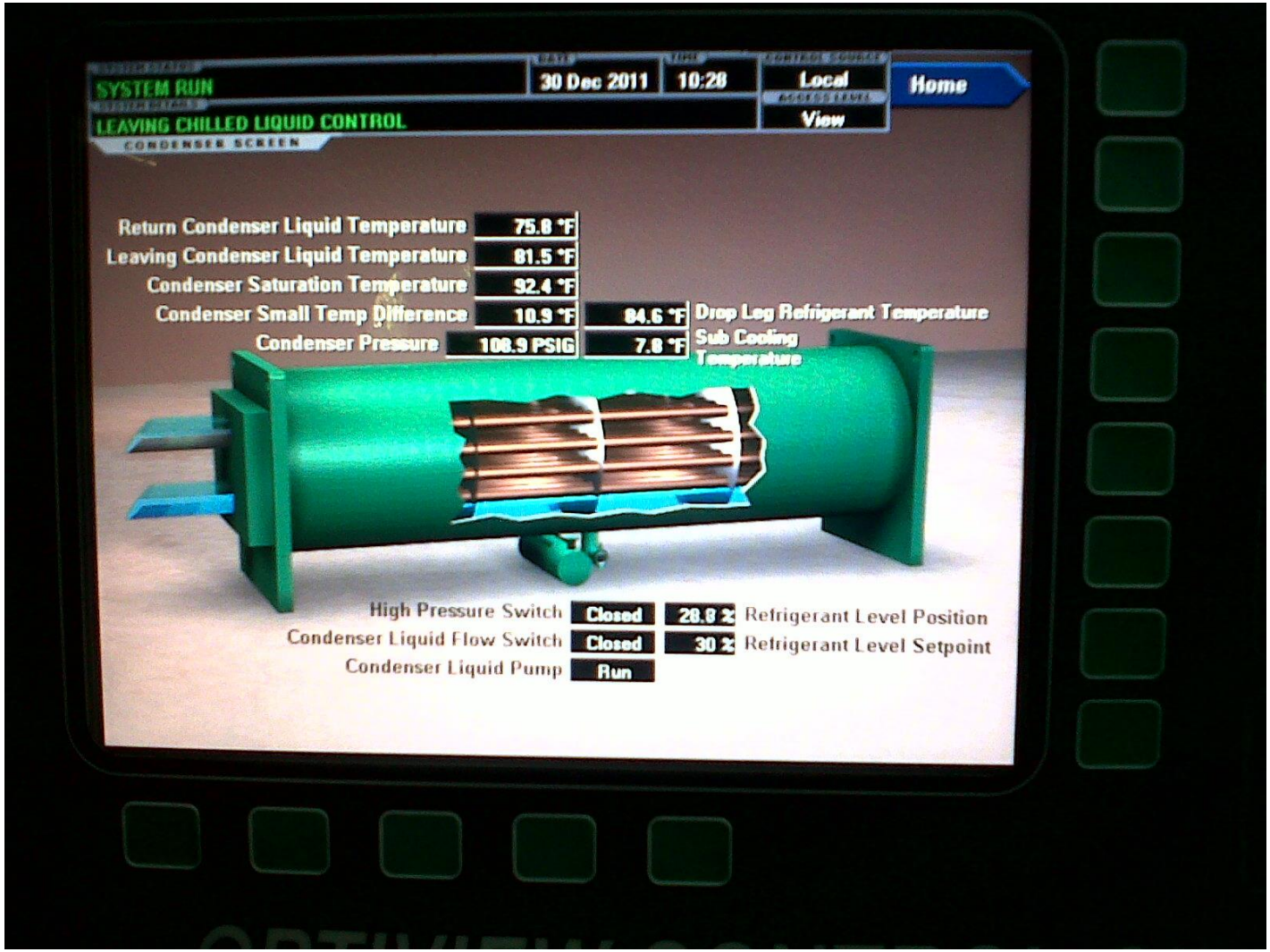
22,953,713 – 21,585,077 = 1,368,636 Baht

Payback Period = 3,000,000 / 1,368,636 = 2.19 Years

Guarantee Saving within 3 years period

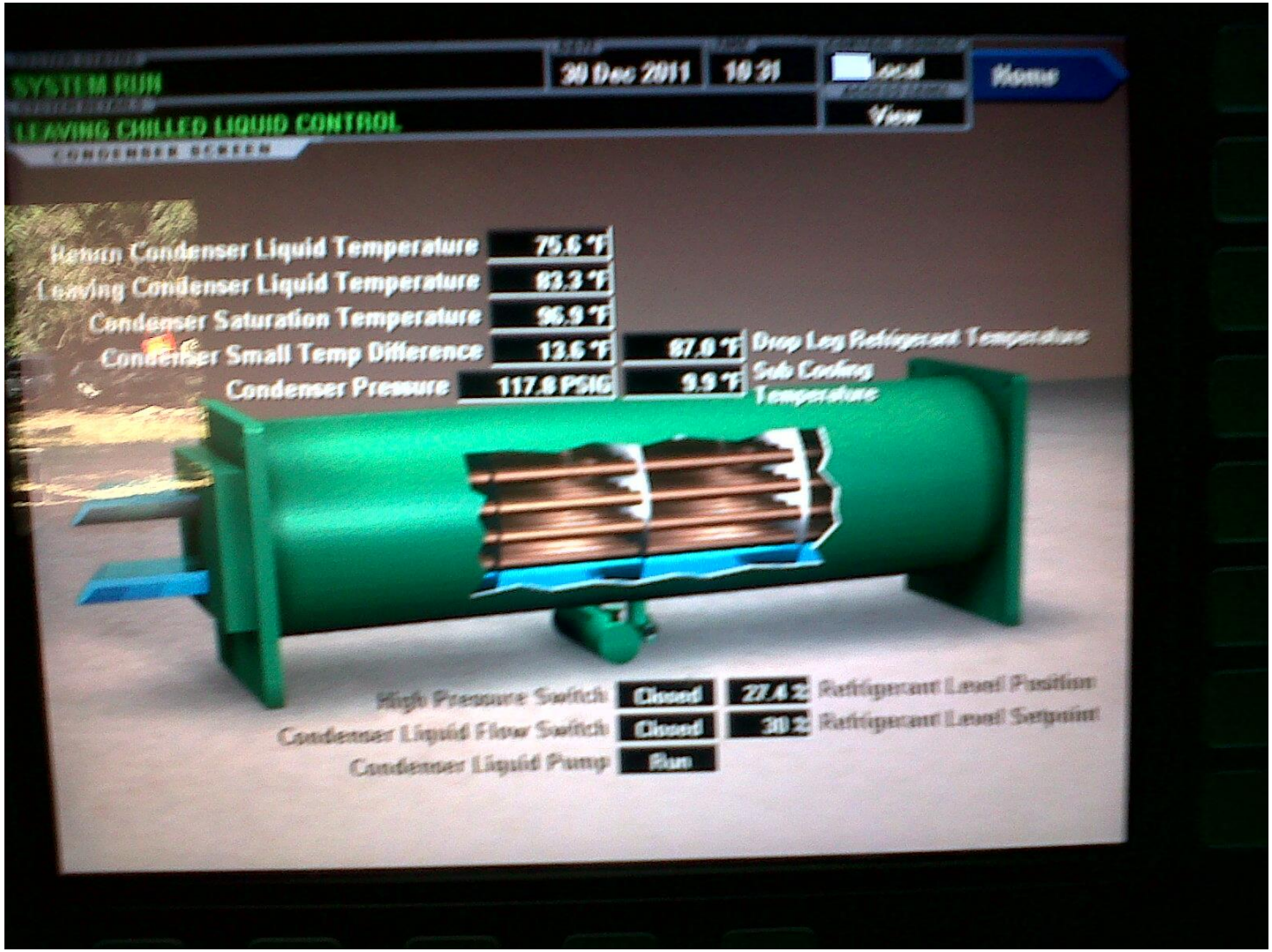
(Guaranteed condenser approach temperature will not increase more than 2^{o}F higher than the condenser approach temperature after de-scaling the condenser tubes during 3 years warranty period)

Chiller # 5 before using ozone treatment



Cond. App. Temp. = 10.9 F

Chiller # 6 before using ozone treatment



Cond. App. Temp. = 13.6 F

Cooling Tower before ozone treatment

Hot basin water of cooling tower

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Cooling Tower before ozone treatment

Algae deposited in hot water basins and water distribution holes become clogged

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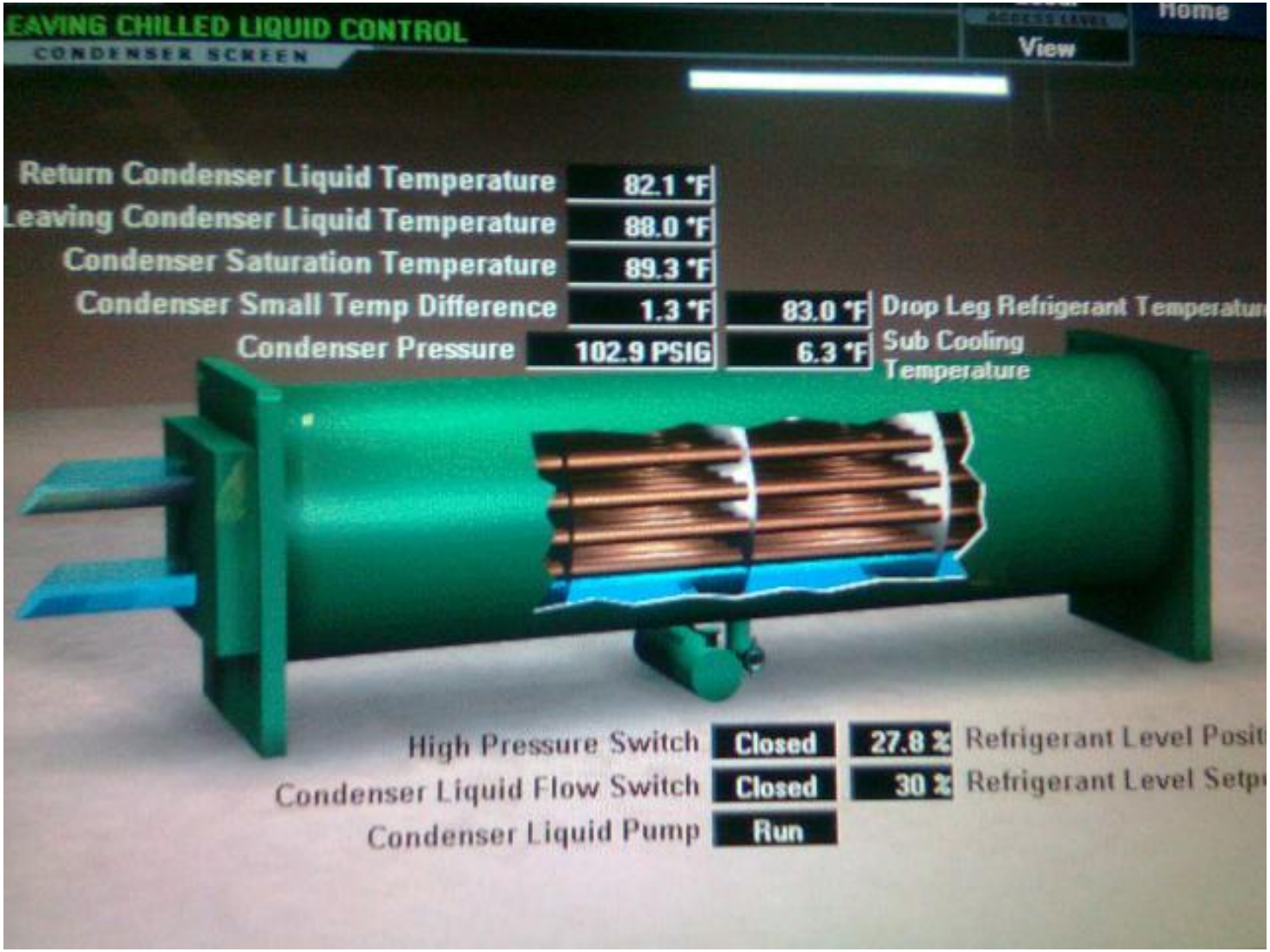
Installed ozone water system 120g/hr

Model: OZG 120 S

Chiller # 5 with ozone treatment after 2 months



Cond. App. Temp. = 1.3 F

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Chiller # 6 with ozone treatment after 2 months

Cond. App. Temp. = 0.7 F

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Cooling Tower with ozone treatment after 2 months

Hot water basin of cooling tower

Chiller conditions with ozone treatment after 10 months

Chiller # 5

- Condenser Approach Temperature = 0.7 F

Chiller # 6

- Condenser Approach Temperature = 0.8 F

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Overall Result

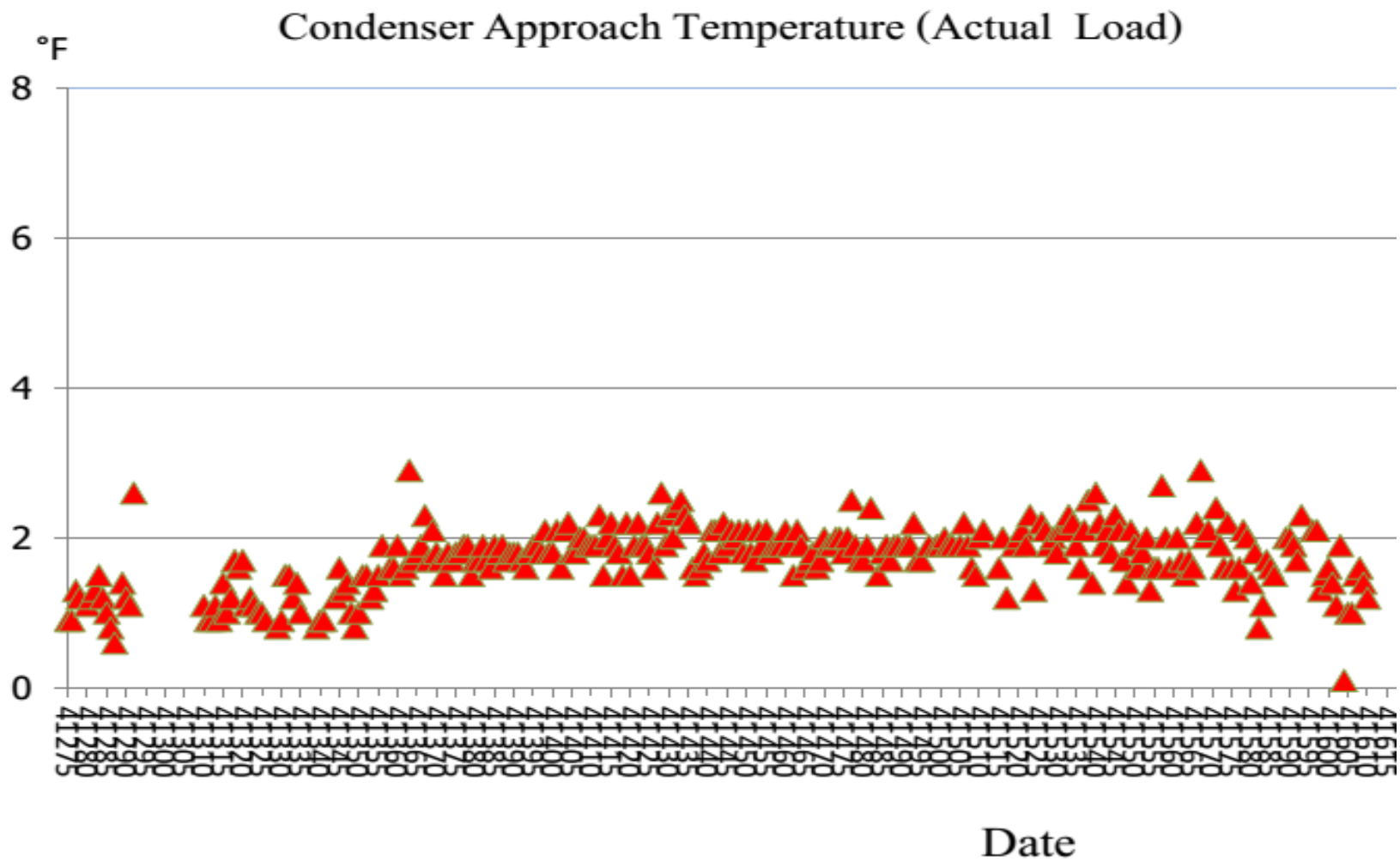
1. Better performance

Before: Chiller 500 TR x 3 Units operate at 100%

Present: Chiller 500 TR x 2 Units operate at 60%

2. Turn-off softener system

3. Turn-off chemicals treatment system


Condenser Approach Temperature (Actual Load)
°F
8
6
4
2
0
Date
App.Temp
App.Temp

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Overall Result From 1 January 2013 to 31 December 2014 Total 730 days

Shut down the water softener system and chemical treatment

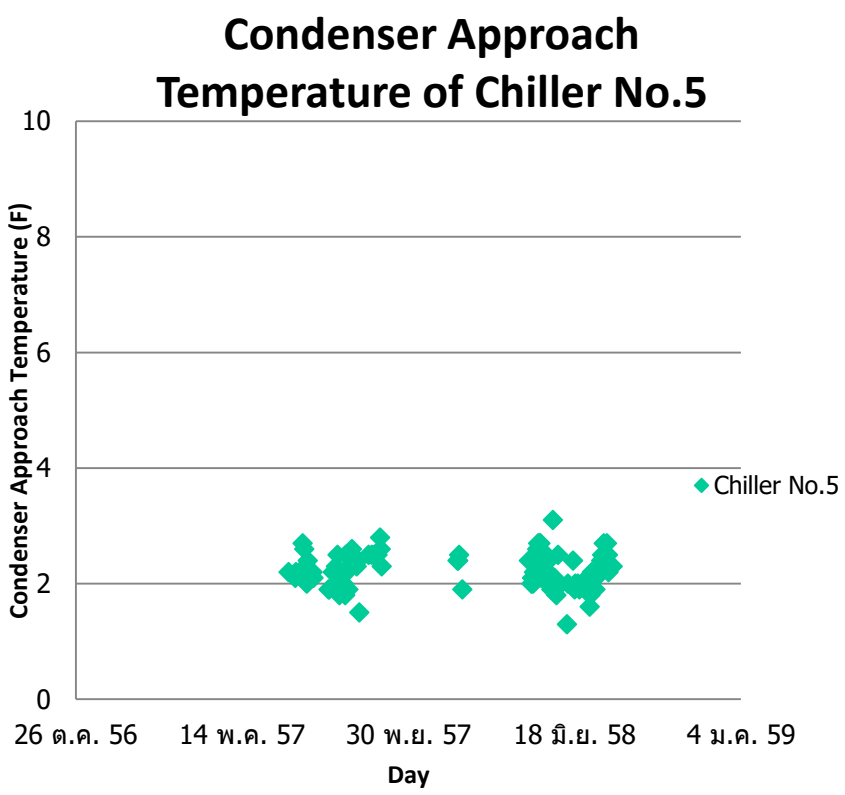
Effect of scale formation on electricity consumption		
Items	Before (As scale formed)	After (As no scale formed)
Chiller No.5	18,720 Baht/Day	14,688 Baht/Day
Chiller No.6	18,720 Baht/Day	14,688 Baht/Day
Chiller No.2	18,720 Baht/Day	Turn-Off

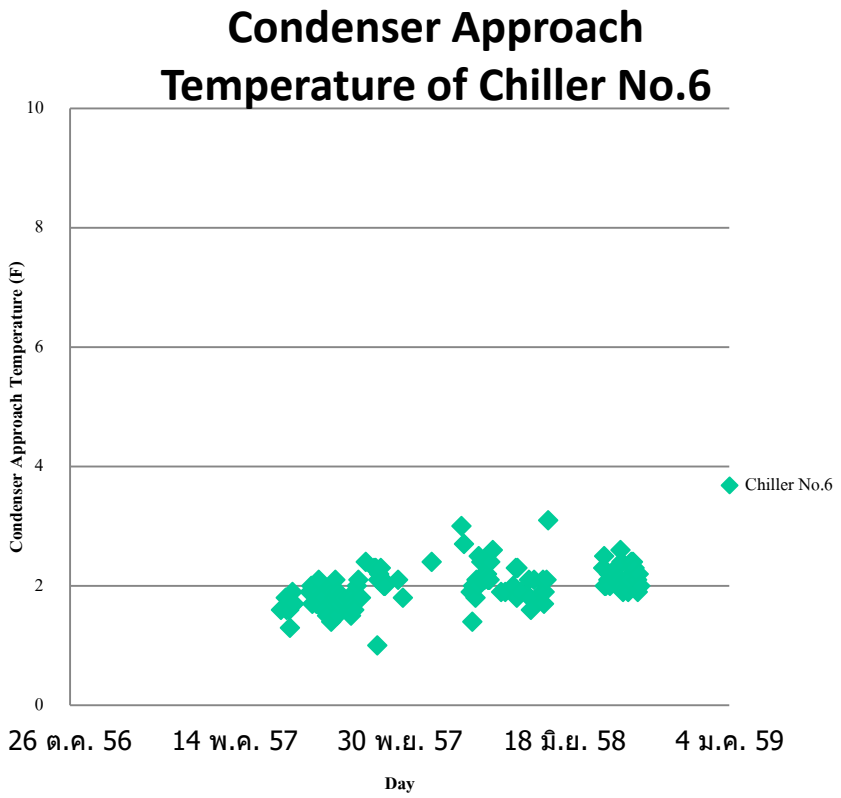
- Reduce Electrical from descaling in condenser (2 condensers) = 14,178,060-13,665,600 = 512,460 Baht
- Reduce Electrical by increasing heat exchange efficiency

  Before : Chiller 500 TR x 3 units @ 100%, After : Chiller 500 TR x 2 units @ 60% Ozone electricity expense 585 Baht/day Daily Saving = (18,720x3 – (14,688x2 + 585)) = 26,199 Baht = 9,562,635 Baht/year

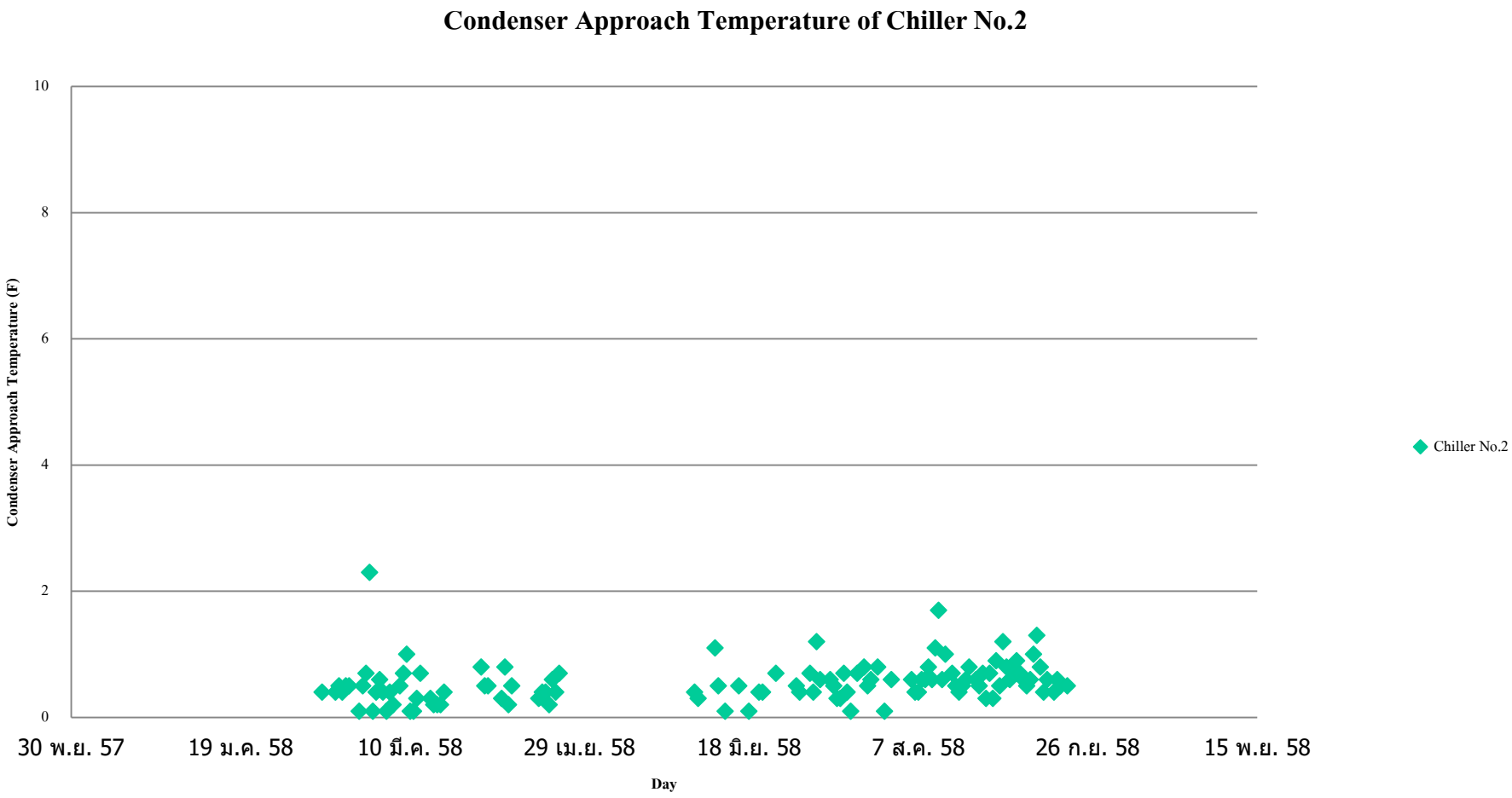
Payback Period = (3,000,000)/(512,460+9,562,635) = 0.3 Years = 3.57 Months

Condenser Approach Temperature Year 4th





Condenser Approach Temperature Chiller No.2 Newly Installed January 2015



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Service and Maintenance with Guaranteed Energy Saving Contract

Alarm Code	Description
E01	No input water
E02	Ventilation fan error
E03	Oxygen generator error
E04	Converter error
E05	Corona discharge error
E06	Clog tube
E07	Power line unbalance and under voltage occur
E08	Door open occur
E09	Ozone gas leakage error
W01	Lack of input water