UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

ASHRAE

Progress and Plans of RP-1677:

Measurement and Prediction of Waterside Fouling Performance of Internally Enhanced Condenser Tubes Used in Cooling Tower Applications

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3. Initial Test Results
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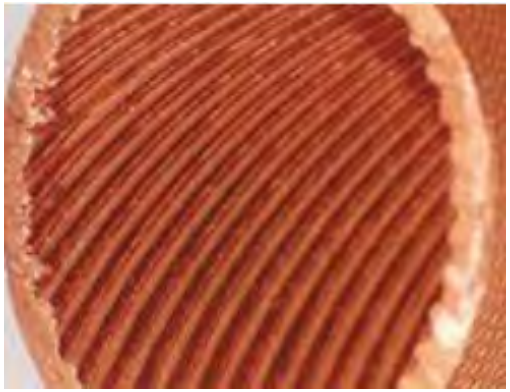
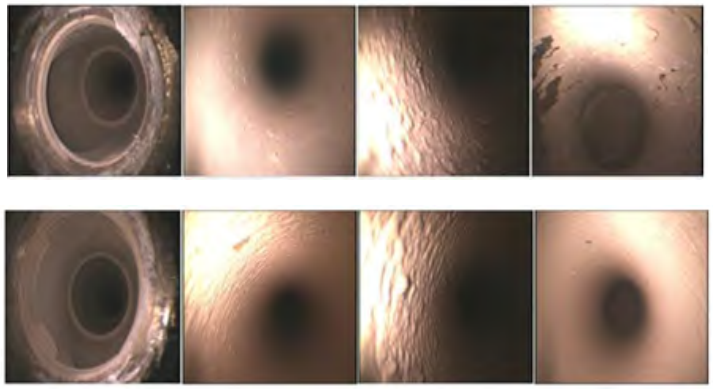
1.1 Background

- Use of enhanced tubes in cooling water tower
- Fouling issues
- Fouling resistance





1.2 Project Objectives

- Experimentally determine the fouling resistance.
- Develop a prediction model.
- Propose a generalized calculation approach.

1.3 Project Tasks

Task 1. Literature Review/Summary (Completed)

Task 2. Experiments and Data Acquisition (In process)

Task 2.1. Build the test system (1/3 completed)

Task 2.2. Make up the test cooling water

Task 2.3. Long-term fouling test

Task 3. Development of Fouling Model

Task 3.1. Develop the correlation of dry matter concentration

Task 3.2. Develop the prediction model of the asymptotic fouling resistance

2. Project Process

Task 1. Literature Review/Summary (Completed)

Title: Fouling of Enhanced Tubes for Condensers Used in Cooling Tower Systems: A Literature Review

Authors: Chao Shen, Chris Cirone, Anthony M. Jacobi, Xinlei Wang

Journal: *Applied Thermal Engineering*, 79 (2015) 74-87.

2. Project Process

Task 2. Experiments and Data Acquisition (on-going)

Task 2.1. Build the test system

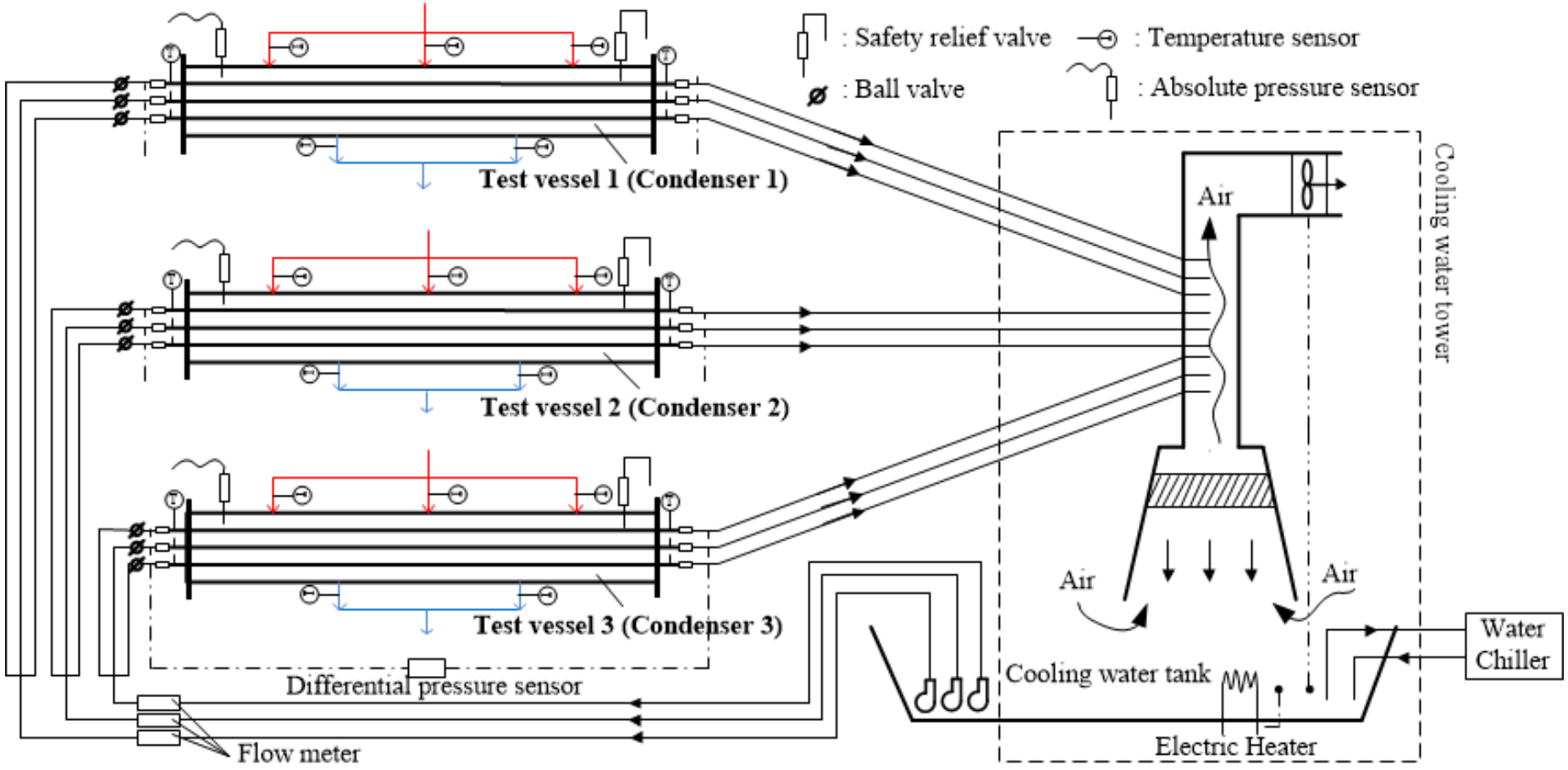
(1) One of the three heat pumps is built

(2) The cooling water tower is built

(3) The data acquisition system is built

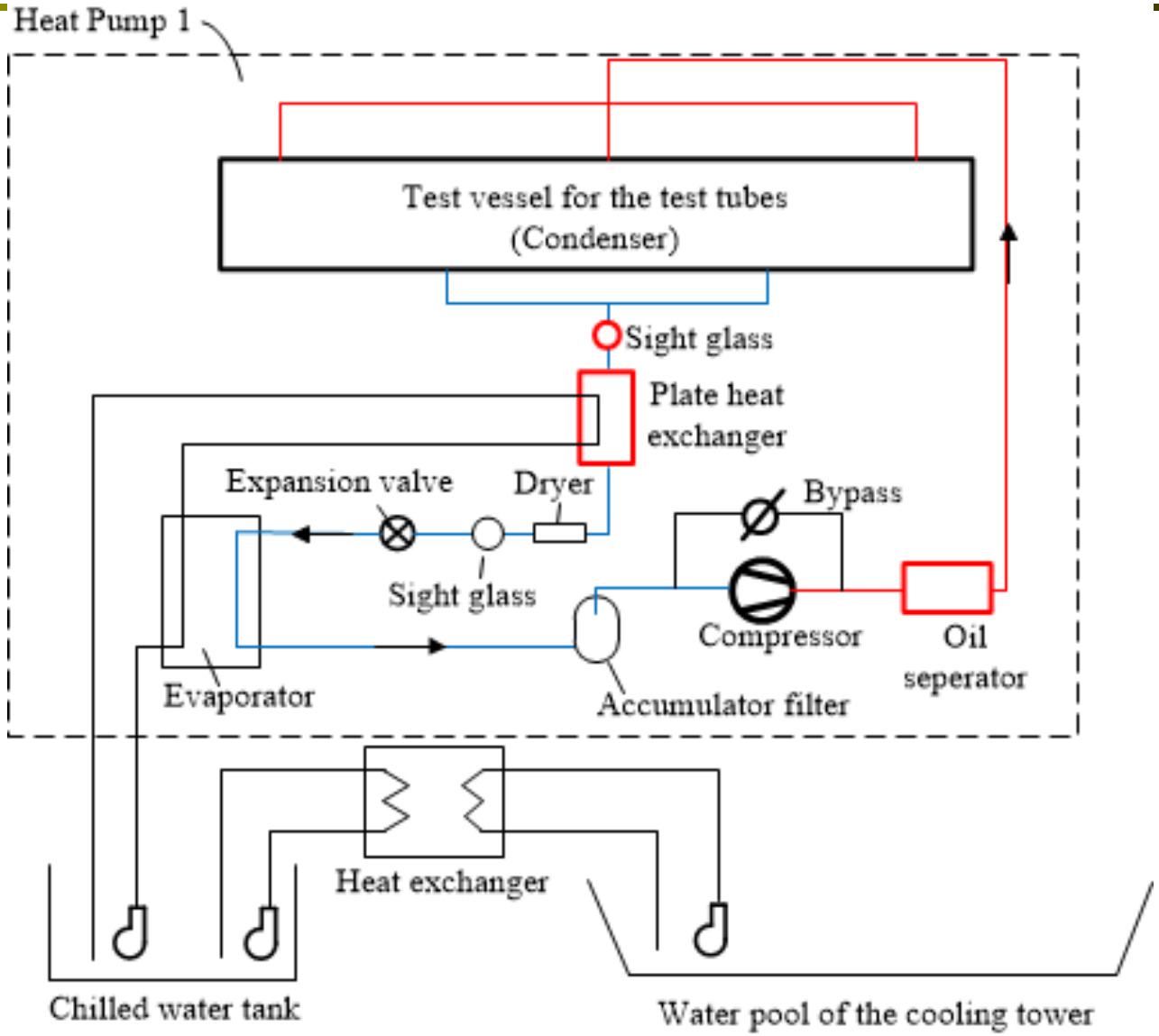
2. Project Process

Schematic of the test system

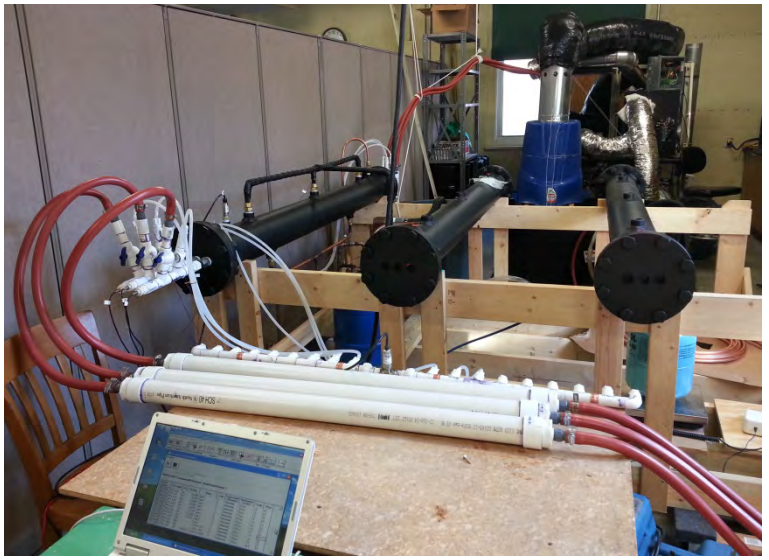


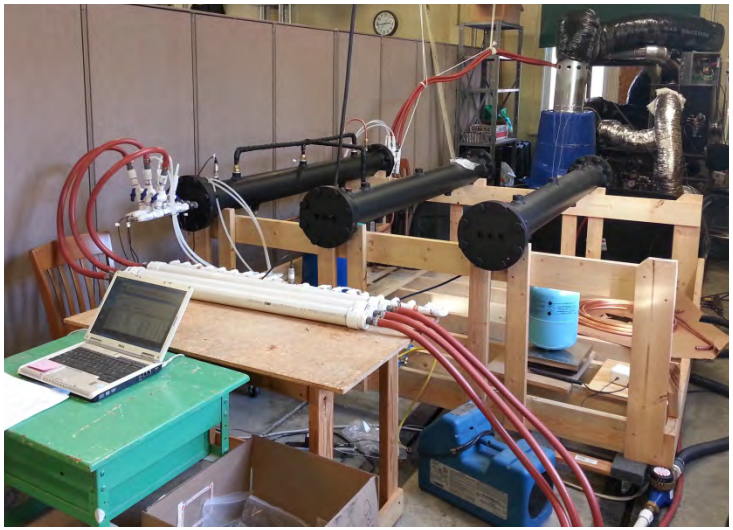
2. Project Process

Schematic of the test system



(1) The heat pump (1/3)

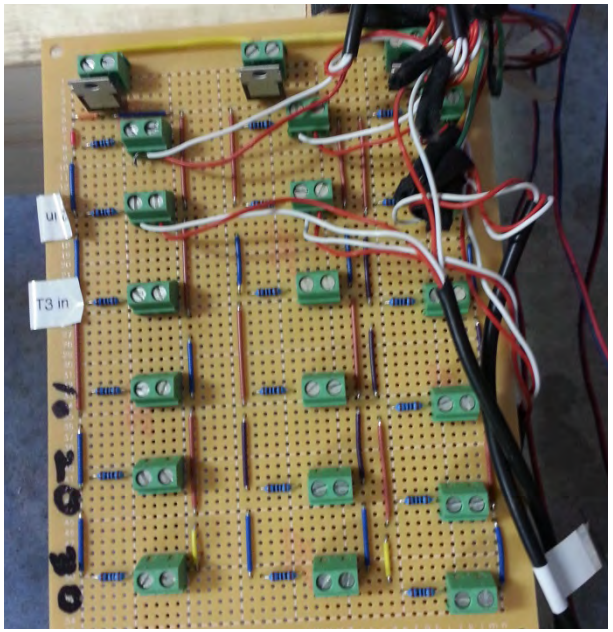


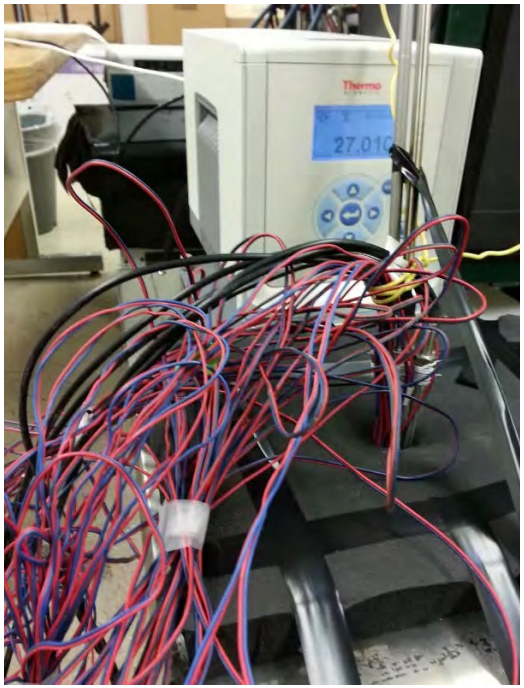


(1) The heat pump (1/3)

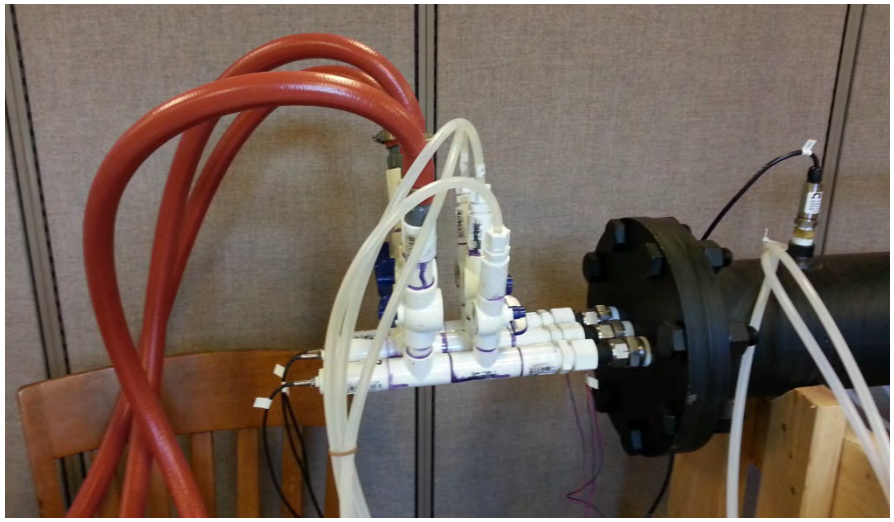
(2) The cooling water tower

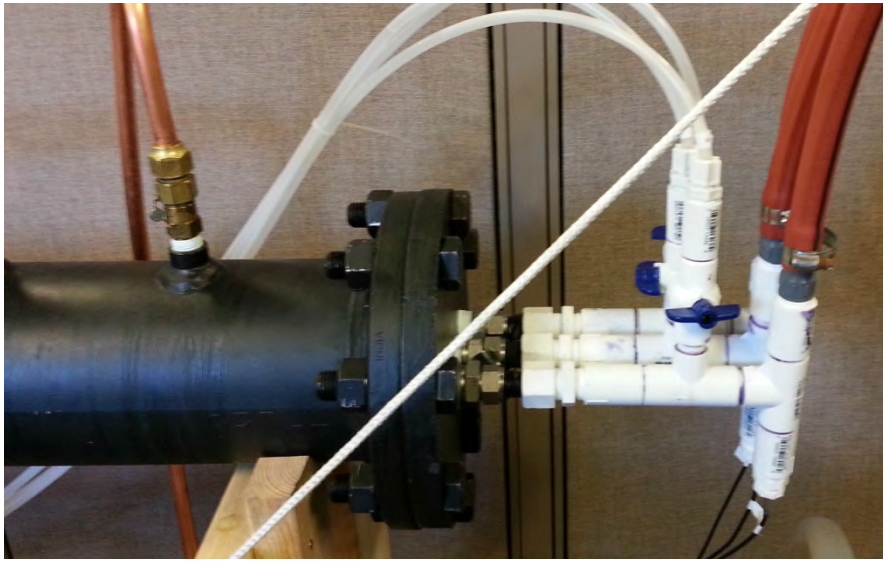
(3) The DAQ and control system

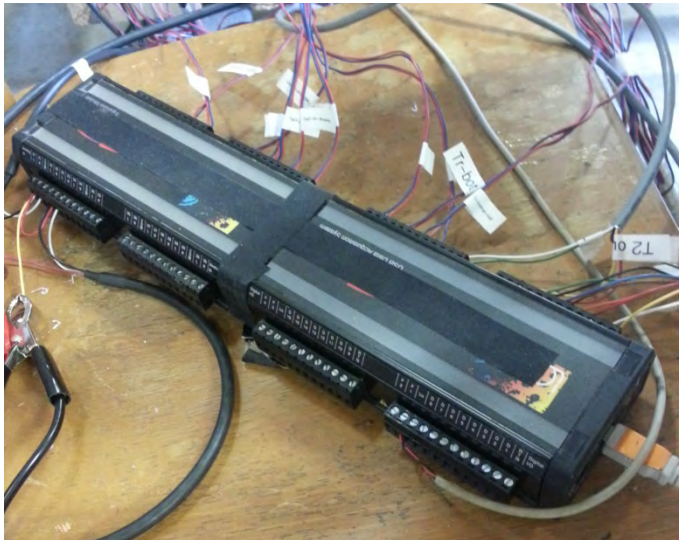




(3) The DAQ and control system







(4) The remaining two heat pumps

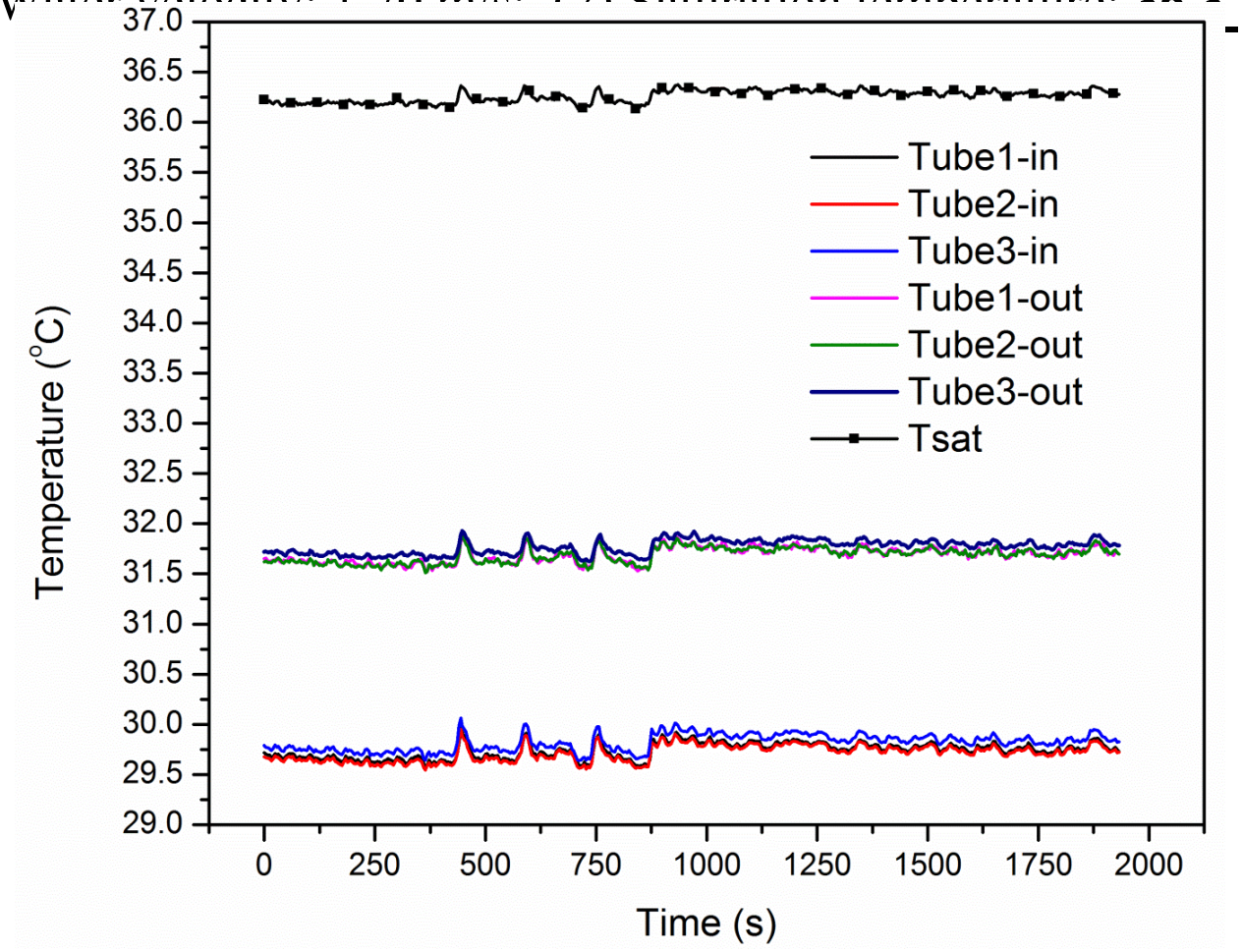
The test tubes are already delivered to our LAB

3. Initial tests

Test	Water velocity	Saturation Temperature	Temperature controller
	m/s	℃	
Test 1	1.70	36.3	Manually
Test 2	0.89	37.4	Controller

3. Initial test results-Test 1

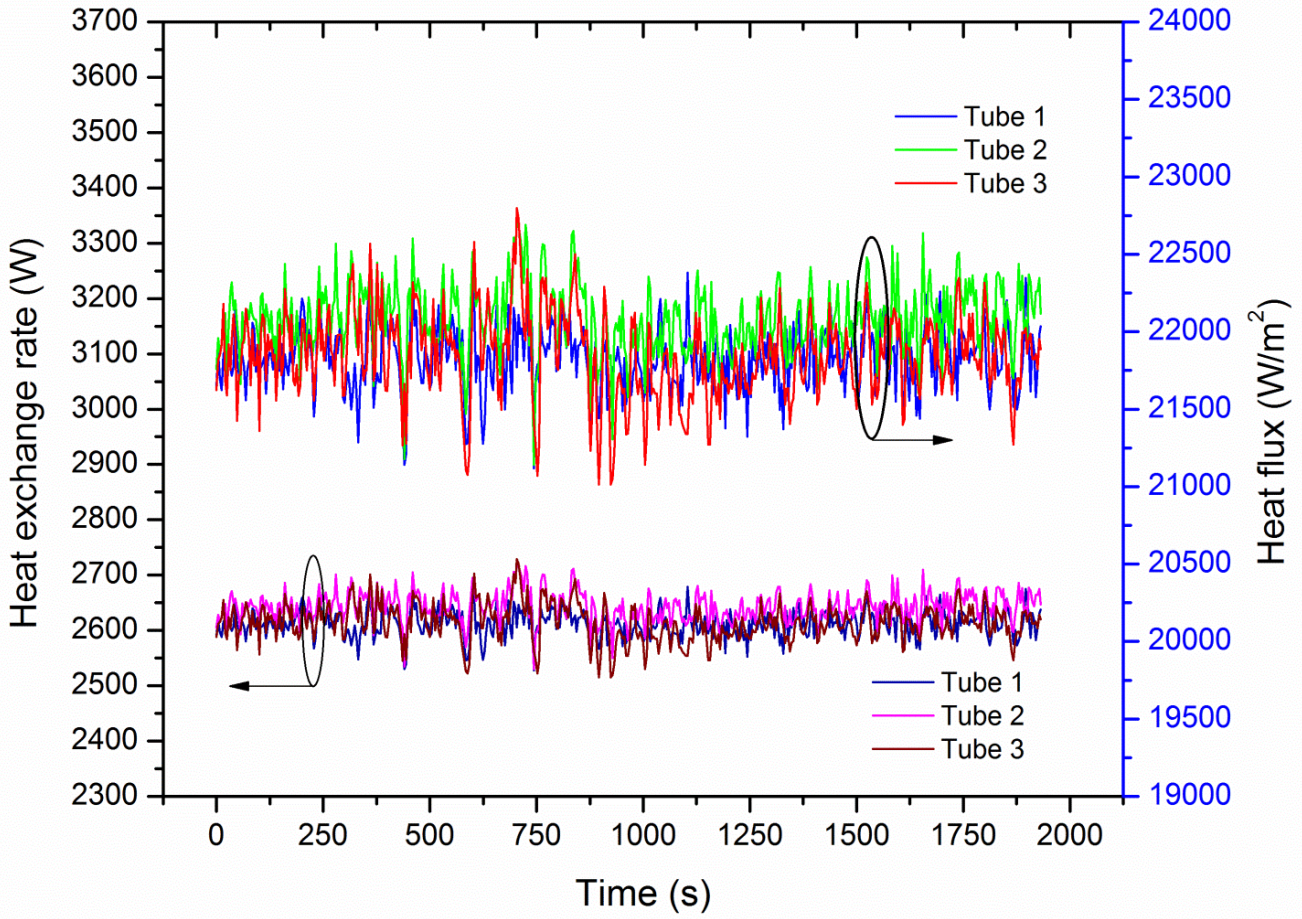
(1)Water velocity: 1.70 m/s; (2) Saturation temperature: 36.3 ℃



Water temperature and saturation temperature of refrigerant

3. Initial test results-Test 1

(1)Water velocity: 1.699 m/s; (2) Saturation temperature: **36.3** ℃



Heat exchange rate and heat flux

3. Initial test results-Test 1

(1)Water velocity: 1.699 m/s; (2) Saturation temperature: **36.3** ℃

Test 2: Cooling-water-side results (averaged)

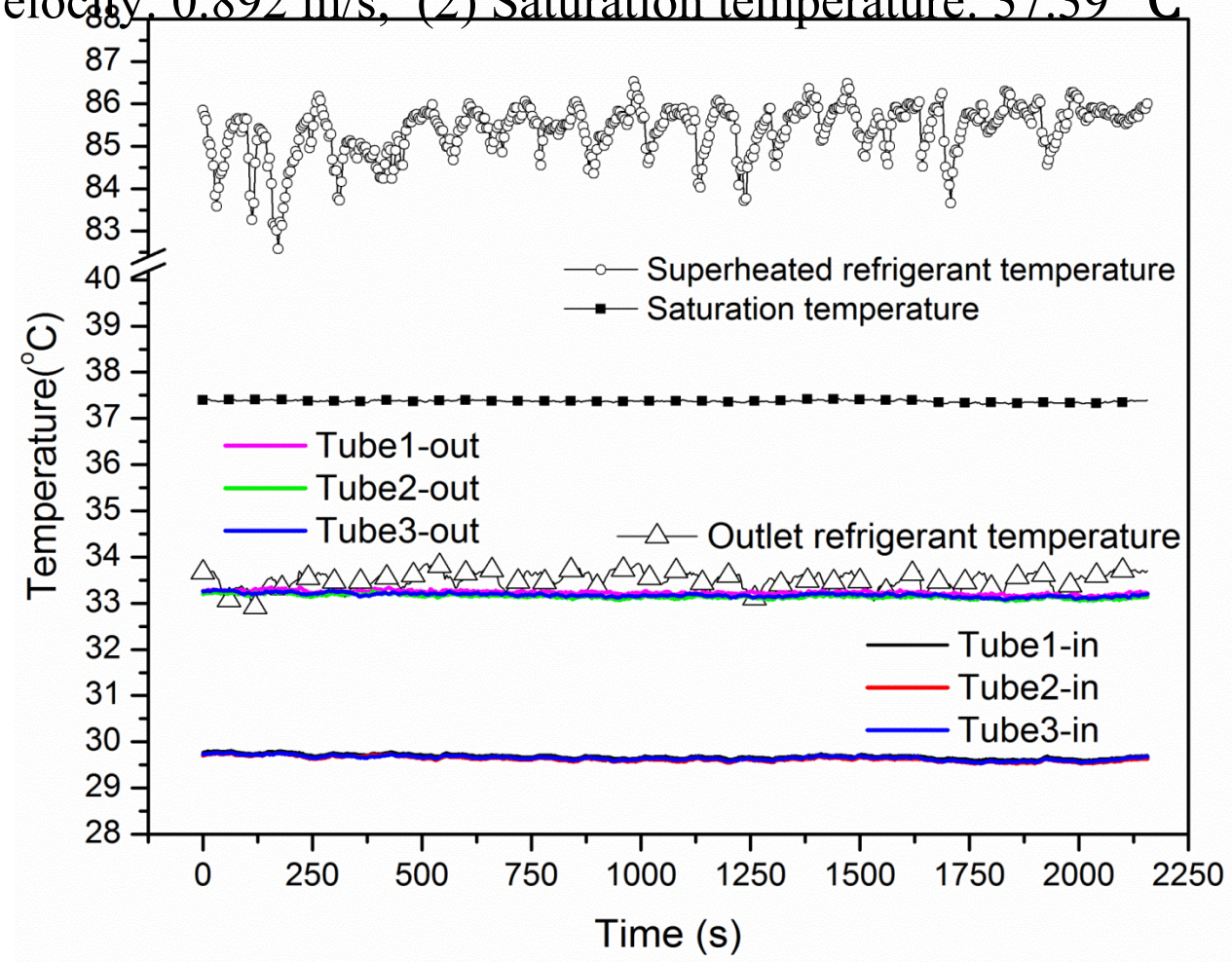
Tube	Water velocity	T-water-in	T-water-out	ΔT-inlet-outlet	Heat exchange rate	Heat Flux	Heat Flux	ΔP-pressure drop
	m/s	°C	°C	°C	W	Btu/hr-ft^2	W/m^2	PSI
1	1.70	29.74	31.69	1.95	2612.3	6918.9	21825.0	1.78
2	1.70	29.72	31.69	1.97	2643.2	7000.7	22083.0	1.66
3	1.70	29.82	31.77	1.95	2614.8	6925.5	21845.8	1.86

Test 2: Refrigerant-side results (averaged)

Saturation Pressure	Saturation Temperature	T-refrigerant-in-middle
PSI	°C	°C
132.5	36.26	78.1

3. Initial test results-Test 2

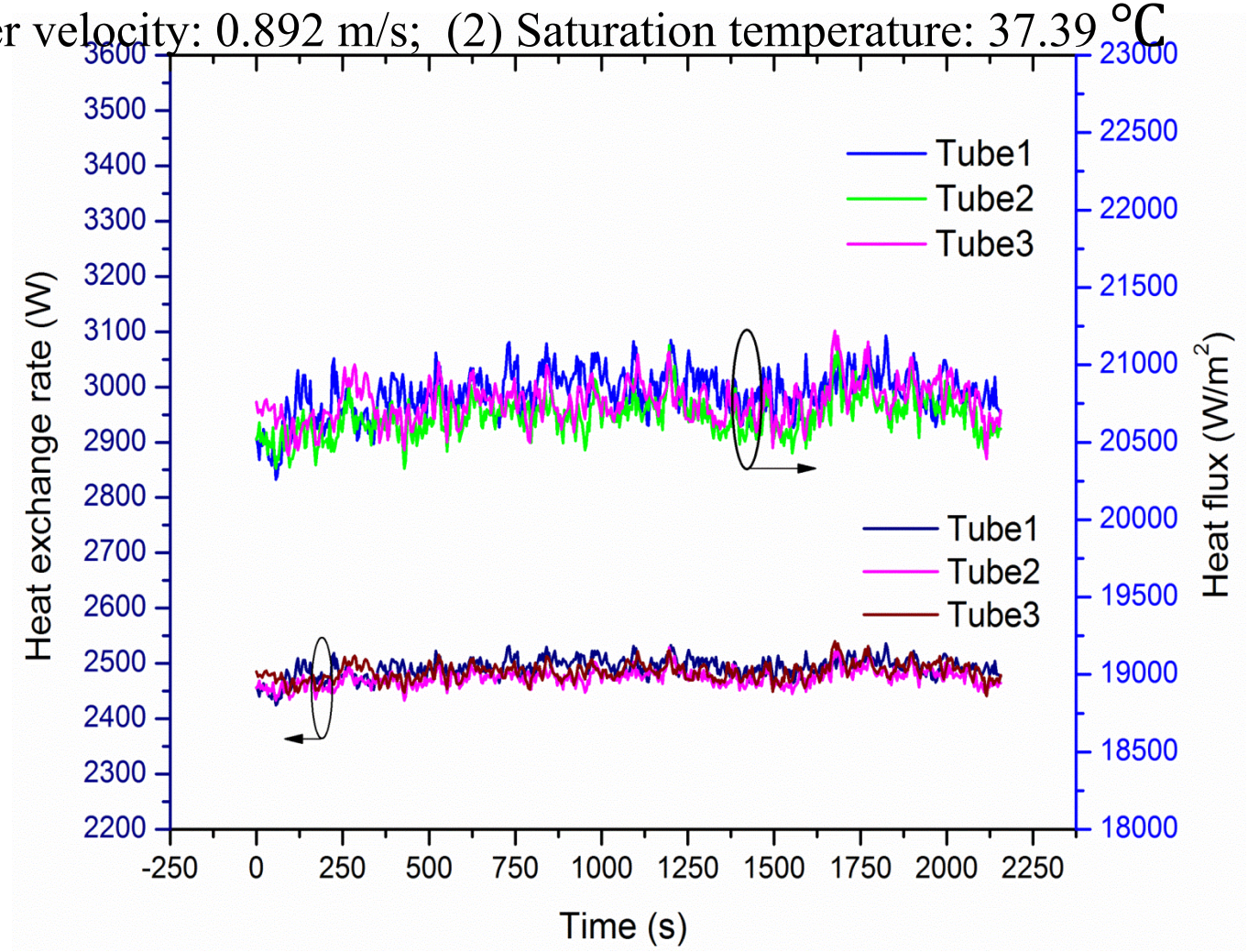
(1)Water velocity: 0.892 m/s; (2) Saturation temperature: 37.39 ℃



Water temperature and saturation temperature of refrigerant

3. Initial test results-Test 2

(1)Water velocity: 0.892 m/s; (2) Saturation temperature: 37.39 °C



Heat exchange rate and heat flux

3. Initial test results-Test 2

(1)Water velocity: 0.89 m/s; (2) Saturation temperature: 37.39 ℃

Test 3: Cooling-water-side results (averaged)

Tube	Water velocity	T-water-in	T-water-out	ΔT-inlet-outlet	Heat exchange rate	Heat Flux	Heat Flux	ΔP-pressure drop
	m/s	°C	°C	°C	W	Btu/HR-ft^2	W/m^2	PSI
1	0.89	29.71	33.25	3.54	2492.77	6602.21	20826.08	0.504
2	0.89	29.65	33.16	3.51	2477.70	6562.30	20700.20	0.502
3	0.89	29.76	33.20	3.53	2488.98	6592.17	20794.42	0.510

Test 3: Refrigerant-side results (averaged)

Saturation Pressure	Saturation Temperature	T-refrigerant-in-middle
PSI	°C	°C
136.34	37.39	85.34

4. Project Plans

- Feb.-Mar. 31, 2015:

  Complete all the construction of the test system

- April-May.15, 2015:

  Make up cooling water, and charge them into the test system to start the fouling test

- May. 15, 2015 - Jan.15, 2017: (20 months)

  Medium fouling potential: 1.6 m/s 4 months

  Medium fouling potential: 0.9 m/s 4 months

  Medium fouling potential: 2.4 m/s 4 months

  High fouling potential: 1.6 m/s 4 months

  Low fouling potential: 1.6 m/s 4 months

4. Project Plan

- During the fouling test (20 months)

  1. Develop the correlation of dry matter concentration of cooling water based on the water quality analysis.

  2. Analyze the fouling data.

- Feb. 1, 2017-April. 30, 2017

  Develop the fouling prediction model based on the test data.

Thanks!
Comments?