FUKUMITSU Pte., Ltd.

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Investigation Report

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1. Introduction:

FUKUMITSU Pte., Ltd. deal with SPACON and new Refrigerants for Air-Con system that can significantly reduce electricity consumption as its main products, and has organized a demonstration test at [redacted], the first demonstration project in Singapore. The main objective of this investigation is proofing the product effects upon existing conditions.

SPACON stands for super condenser and is a product that can reduce the amount of electricity used by approximately 10% by installing it in existing outdoor units. By installing the SPACON, the refrigerant passing through the SPACON can be cooled by a further 3°C to 5°C, and by reducing the pressure in the refrigerant pipes, the compressor's power consumption can be reduced. In addition, the liquefaction of the refrigerant can be promoted and the cooling capacity can be improved. The above shows that the purpose of using the SPACON is to reduce electricity consumption, but it was also effective in reducing the high voltage cut-off outdoor units under severe temperature conditions.

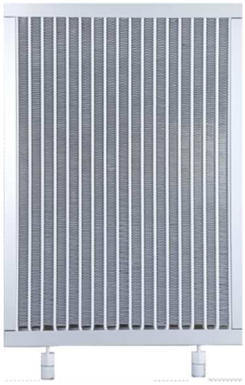

Table 1.1 SPACON

Table 1.2 SPACON - Section

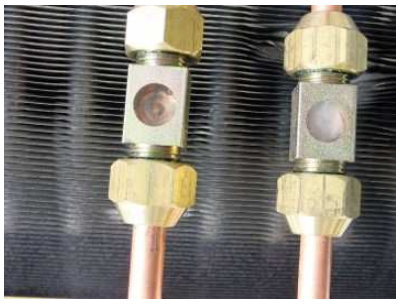

Table 1.3
Improvement of Liquefaction

The refrigerants dealt by FUKUMITSU have the effect of reducing the pressure in the refrigerant pipes without reducing the cooling capacity, and the static pressure in the refrigerant pipes can be 15% to 20% lower than that of refrigerants normally used. This can reduce electricity consumption by more than 10%.

In this demonstration test, refrigerant was installed in Chiller No. 1 and Chiller No. 2 at the [redacted] plant room, and a total of eight (8) LD-type SPACONs were installed in Chiller No. 2, in order to verify the power reduction effect of installing SPACONs and refrigerants.

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Table 1.4 SPACON Installation @Chiller No.2

Table 1.5 SPACON - OFF

Table 1.6 SPACON - ON

2. Testing Method

Measure and compare the current values of Chiller No. 1 and Chiller No. 2 before and after the applying of refrigerant. SPACON is installed in advance and bridged piping is provided with a valve so that the use of SPACON can be switched when piping refrigerant.

Table 2.1 Bridge Piping

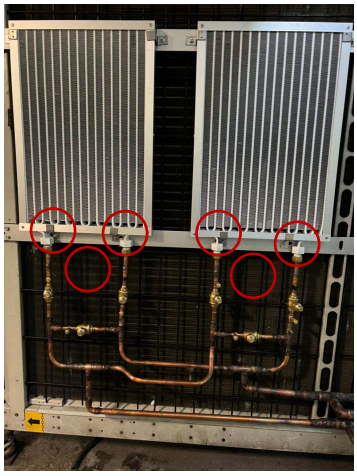
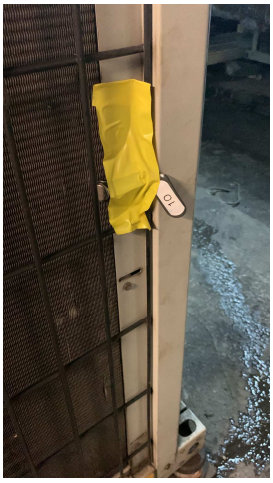
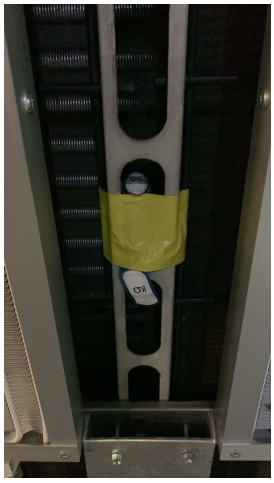


Table 2.2 Setting Status for Intake Temperature Logger





In order to understand the various conditions during compressor operation, the intake air temperature of the outdoor unit and the temperature of the chilled water supply and return from the chiller are measured, and from the data measured over a certain period, the intake air temperature and the temperature difference between the chilled water supply and return, which affect the compressor's electricity consumption, are extracted under almost identical conditions. And the current data shall be extracted and compared under the above conditions.

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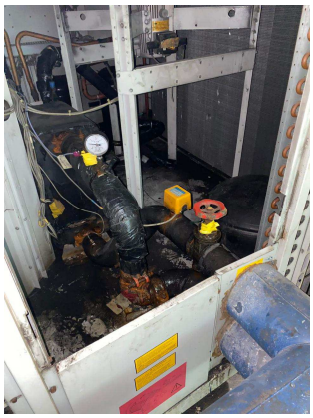
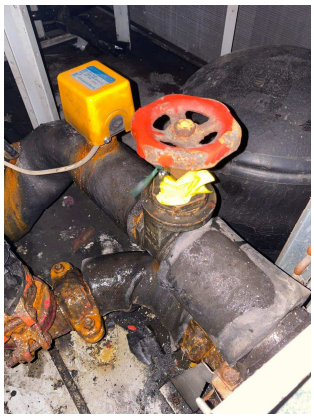
Table 2.3 Setting Status for Cooling Water Temperature Logger





3. **Testing Equipment:**

Electrical Logger - KYORITSU KEW LOGGER 5020
Logger Clump Sensor – KEW 8122

Table 3.1 Current Logger

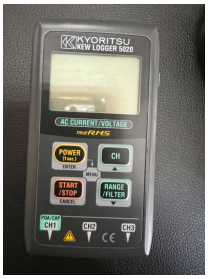


Table 3.2 Logger Clump

Temperature Logger - KN Laboratories, Inc.

Table 3.3 Temp. Logger

Table 3.4 Temp. Logger

Table 3.5 Logger Reader

4. **Demonstration Schedule**

All the demonstration was carefully decided and adjusted NOT to affect the tenant operation as follows;

1. Installed SPACON on [redacted]
2. Connecting SPACON refrigerant pipes to Chiller No.2 on [redacted]
3. [redacted] - Basic Data of existing conditions
4. Refrigerant replacement of Chiller No.1 and No.2 on [redacted]
5. [redacted] - Measuring the effectiveness of refrigerant gas
6. - Measuring the effectiveness of Hybrid System (SPACON + Refrigerant)

5. **Investigation**

5.1 Basic conditions for verification

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The compressor availability (power consumption) depends on the following conditions

1. Intake air temperature to the outdoor unit
2. Heat Load at required indoor cooling conditions
3. Pressure in the refrigerant pipes

We understand that the exact reduction amount of consumption for electricity by Refrigerant and SPACON is difficult unless otherwise tested in a constant-temperature room, therefore it is necessary to consider situations that come as close as possible to the above conditions and to conduct verification in accordance with actual operations.

Firstly, the intake air temperature to the outdoor unit is affecting the performance of the compressor. For accurate comparisons purpose, closer intake air temperatures are necessary.
However, if the intake air temperatures are not the same, the Air-Con. manufacturers provide adjusted values for electricity consumption by intake air temperature compensation so that we can compensate for the consumption as per existing temperature. Table 5.1.1 is showing the compensation value provided by Carrier Singapore for this Chiller Model. If the intake air would be different 1 degree from the others, the electricity consumption for the compressor will be 1.82% difference according to Table 5.1.1.

Secondly, the heat load under required indoor conditions is also affecting the power consumption. If the heat load is higher than the others, the operating rate of the compressor will increase by that much. Thus, the operating conditions of the compressor vary depending on the amount of heat load in the room and affecting the measured current value. Since the return chilled water temperature is expected to reflect the indoor heat load conditions, the return chilled water temperature shall be used to adjust the current value to reflect the heat load in the room as similar as we can.

The current value is adjusted by the following.

1. Adjust the current value measured every 5 minutes using the compensation value by the temperature at the time of measurement.
2. The current value per unit of chilled water temperature (A/℃) is calculated by dividing the above adjusted current value by the return chilled water temperature that is thought to reflect the indoor heat source.
3. Compare the current value per unit of chilled water temperature to confirm the effect of reduced electricity consumption.

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Table 5.1.1 Cooling Capacity compensation value provided by Carrier

		Outside air temperature °C														
		25			30			35			40			45		
Model	LWT	CAP	COMP	FLOW	CAP	COMP	FLOW	CAP	COMP	FLOW	CAP	COMP	FLOW	CAP	COMP	FLOW
	°C	kW	kW	l/s	kW	kW	l/s	kW	kW	l/s	kW	kW	l/s	kW	kW	l/s
039S	5	40.9	10.7	2.0	39.2	11.6	1.9	37.4	12.8	1.8	35.1	14.0	1.7	32.5	15.6	1.6
060S	5	62.8	16.4	3.0	59.9	18.1	2.9	55.9	20.1	2.7	51.2	22.2	2.4	46.3	24.7	2.2
080S	5	85.4	23.4	4.1	80.7	25.4	3.9	75.6	27.0	3.6	70.0	30.5	3.3	64.0	33.4	3.1
100S	5	107.1	27.8	5.1	101.6	30.4	4.9	95.3	33.3	4.5	88.2	36.6	4.2	80.4	40.0	3.8
120S	5	125.6	34.3	6.0	118.9	36.8	5.7	111.8	39.6	5.3	104.2	42.7	5.0	95.4	46.7	4.6
160S	5	167.3	45.2	8.0	158.2	49.0	7.6	148.3	53.1	7.1	137.6	57.8	6.6	125.9	63.1	6.0
039S	6	42.1	10.8	2.0	40.4	11.7	1.9	38.5	12.9	1.8	36.1	14.2	1.7	33.5	15.7	1.6
060S	6	65.0	16.5	3.1	62.1	18.3	3.0	57.8	20.3	2.8	53.1	22.4	2.5	48.0	24.8	2.3
080S	6	87.9	23.6	4.2	83.1	25.6	4.0	77.8	27.3	3.7	72.1	30.7	3.4	66.0	33.6	3.1
100S	6	110.2	28.2	5.3	104.6	30.8	5.0	98.0	33.7	4.7	90.8	37.0	4.3	82.8	40.4	4.0
120S	6	129.0	35.1	6.2	122.2	37.7	5.8	114.9	40.4	5.5	107.0	43.6	5.1	98.4	47.0	4.7
160S	6	172.6	45.9	8.2	163.2	49.7	7.8	153.0	53.9	7.3	141.9	58.6	6.8	129.9	63.9	6.2
039S	7	43.3	10.9	2.1	41.5	11.8	2.0	39.7	13.0	1.9	37.1	14.3	1.8	34.4	15.9	1.6
060S	7	67.2	16.6	3.2	64.2	18.4	3.1	59.8	20.4	2.9	55.0	22.5	2.6	49.7	25.0	2.4
080S	7	90.5	23.8	4.3	85.6	25.9	4.1	79.9	27.5	3.8	74.3	30.9	3.5	67.8	33.8	3.2
100S	7	113.5	28.6	5.4	107.7	31.2	5.1	100.9	34.4	4.8	93.4	37.5	4.5	85.2	40.9	4.1
120S	7	132.6	35.8	6.3	125.5	38.5	6.0	118.0	41.7	5.6	109.8	44.5	5.2	101.0	47.8	4.8
160S	7	178.1	46.7	8.5	168.4	50.5	8.0	157.9	54.8	7.5	146.5	59.5	7.0	134.1	64.7	6.4
039S	8	44.5	11.1	2.1	42.7	12.0	2.0	40.7	13.2	1.9	38.2	14.5	1.8	35.4	16.1	1.7
060S	8	69.4	16.8	3.3	66.4	18.6	3.2	61.9	20.6	3.0	56.9	22.7	2.7	51.5	25.1	2.5
080S	8	93.2	24.1	4.5	88.0	26.1	4.2	82.4	27.8	3.9	76.5	31.2	3.7	69.8	34.2	3.3
100S	8	116.8	29.0	5.6	110.7	31.7	5.3	103.7	34.7	5.0	96.1	38.0	4.6	87.6	41.4	4.2
120S	8	136.4	36.2	6.5	128.8	39.3	6.2	121.0	42.3	5.8	112.6	45.5	5.4	103.6	48.8	4.9
160S	8	183.6	47.5	8.8	173.5	51.3	8.3	162.8	55.6	7.8	151.1	60.4	7.2	138.4	65.5	6.6
039S	10	46.9	11.3	2.2	45.1	12.3	2.2	43.0	13.5	2.1	40.3	14.8	1.9	37.3	16.4	1.8
060S	10	74.0	17.1	3.5	70.7	18.8	3.4	66.1	20.9	3.2	60.9	23.0	2.9	55.3	25.5	2.6
080S	10	98.6	24.6	4.7	93.2	26.6	4.5	87.4	28.3	4.2	81.0	31.7	3.9	74.0	34.6	3.5
100S	10	123.5	29.9	5.9	117.0	32.6	5.6	109.5	35.6	5.2	101.4	38.9	4.8	92.4	42.4	4.4
120S	10	143.9	37.1	6.9	136.0	40.2	6.5	127.5	43.7	6.1	118.4	47.4	5.7	108.7	50.7	5.2
160S	10	195.1	48.5	9.3	184.4	52.8	8.8	172.9	57.4	8.3	160.6	62.2	7.7	147.2	67.4	7.0

Legend:
LWT leaving water temperature
CAP cooling capacity
COMP compressor power input
FLOW water flow

Application data:
Standard units, refrigerant: HFC-410A
Evaporator temperature rise: 5°C
Fouling factor: 0.018 m^2K/kW

In this verification, we shall guess, choose and compare a similar intake air temperature date as well as similar conditions of heat load date in the room in accordance with the above reasons from the Chiller Operation Conditions in accordance with Sub-Clause 5.2.

The verification is considered only tenant operating hours to reflect the actual reduction of consumption of electricity which particularly affects compressor operation, and excluded the 1 hour after opening and before closing (10:30-11:30, 18:30-19:30) as changes in indoor heat load from opening to closing are likely to be particularly significant.

5.2 Chiller conditions for comparison

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In this investigation under conditions of Clause 4, we verified 3 different cases of the Chiller Operation Conditions as below.

A. **Basic Data - Existing Conditions : No-SPACON with R410A (Conditions A)**
B. **Proposal 1 - No-SPACON with proposed Refrigerant (Conditions B)**
C. **Proposal 2 – SPACON with proposed Refrigerant - Hybrid System (Conditions C)**

We verified the power consumption ratio of the proposed Conditions B and C against the power consumption in work Condition A. The dates of obtaining verification data corresponding to each operation condition will be as follows.

Conditions A : [redacted]
Conditions B : [redacted]
Conditions C : [redacted]

Since Table 5.1.1 is based on the assumption that the intake air temperature is set normally 35°C and the chilled water temperature setting is 7°C, [redacted], when the intake air temperature is close to 35°C, is set as the reference date for the current verification for Conditions A.

Considering the heat load inside the room, the weekday of [redacted] would be compared with the other weekday, and a similar day as a reference date is preferred too. Thus, the Conditions B and C shall be [redacted].

In view of the foregoing, we compare the electricity consumption status on [redacted] (Conditions A) with [redacted] (Conditions B) and [redacted] (Conditions C) in this verification.

5.3 Verification

Table 5.3.1 shows the actual current measurements and Table 5.3.2 shows the adjusted current values based on Table 5.1.1.
Fig. 5.3.1 shows the temperature variation on the day of measurement, and Fig. 5.3.2 shows the relationship between the current values before and after adjustment.

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Table 5.3.1 Actual Current Measurement

	[redacted]											
	CH1		CH2		CH1		CH2		CH1		CH2	
	Current	Temp.	Current	Temp.	Current	Temp.	Current	Temp.	Current	Temp.	Current	Temp.
11:30:26	118.4 A	33.0 ℃	85.6 A	33.5 ℃	86.6 A	40.0 ℃	110.9 A	35.3 ℃	91.2 A	35.3 ℃	112.3 A	36.8 ℃
11:35:26	117.9 A	33.3 ℃	85.8 A	34.3 ℃	115.7 A	40.0 ℃	111.6 A	35.0 ℃	91.3 A	36.0 ℃	113.1 A	37.0 ℃
11:40:26	117.6 A	33.5 ℃	85.4 A	33.5 ℃	89.0 A	40.0 ℃	112.4 A	35.0 ℃	91.4 A	35.5 ℃	113.3 A	36.8 ℃
11:45:26	117.8 A	33.3 ℃	85.6 A	34.0 ℃	60.6 A	40.0 ℃	112.1 A	35.5 ℃	92.0 A	36.8 ℃	113.5 A	36.0 ℃
11:50:26	117.7 A	33.5 ℃	85.7 A	33.8 ℃	60.7 A	39.5 ℃	112.1 A	35.0 ℃	92.6 A	36.8 ℃	113.8 A	36.5 ℃
11:55:26	90.4 A	33.5 ℃	85.9 A	33.5 ℃	60.6 A	39.5 ℃	112.0 A	35.8 ℃	92.6 A	37.0 ℃	113.1 A	36.3 ℃
12:00:26	90.1 A	33.0 ℃	86.0 A	34.0 ℃	61.6 A	39.5 ℃	112.3 A	36.0 ℃	92.2 A	37.0 ℃	113.2 A	36.3 ℃
12:05:26	118.6 A	32.5 ℃	85.5 A	34.0 ℃	61.2 A	40.0 ℃	112.9 A	35.5 ℃	92.0 A	37.0 ℃	114.4 A	37.0 ℃
12:10:26	118.8 A	32.5 ℃	86.3 A	34.3 ℃	61.3 A	39.5 ℃	112.5 A	36.0 ℃	93.2 A	37.3 ℃	114.7 A	37.8 ℃
12:15:26	118.5 A	32.8 ℃	86.0 A	34.3 ℃	61.4 A	39.5 ℃	112.8 A	35.8 ℃	93.2 A	38.0 ℃	114.6 A	37.3 ℃
12:20:26	118.9 A	32.8 ℃	85.9 A	34.3 ℃	61.6 A	39.5 ℃	114.0 A	35.3 ℃	93.7 A	37.5 ℃	114.3 A	38.0 ℃
12:25:26	118.5 A	33.0 ℃	85.9 A	34.0 ℃	61.5 A	39.5 ℃	113.5 A	35.0 ℃	93.0 A	37.3 ℃	115.1 A	38.3 ℃
12:30:26	118.2 A	33.3 ℃	85.9 A	33.3 ℃	61.7 A	40.0 ℃	113.1 A	35.8 ℃	93.2 A	38.0 ℃	114.1 A	38.3 ℃
12:35:26	90.5 A	33.0 ℃	86.3 A	33.5 ℃	61.2 A	40.0 ℃	112.5 A	36.0 ℃	92.9 A	37.0 ℃	114.4 A	38.3 ℃
12:40:26	90.9 A	32.8 ℃	86.5 A	34.0 ℃	62.3 A	40.0 ℃	113.3 A	36.0 ℃	92.0 A	37.8 ℃	114.7 A	38.3 ℃
12:45:26	118.5 A	33.0 ℃	86.1 A	34.0 ℃	61.5 A	40.0 ℃	112.9 A	35.5 ℃	93.8 A	38.3 ℃	114.9 A	38.3 ℃
12:50:26	118.3 A	32.8 ℃	86.4 A	34.3 ℃	61.7 A	39.5 ℃	113.9 A	35.5 ℃	92.8 A	37.5 ℃	114.3 A	38.8 ℃
12:55:26	118.5 A	33.0 ℃	86.1 A	34.0 ℃	61.9 A	40.0 ℃	113.4 A	36.0 ℃	93.4 A	37.8 ℃	114.7 A	38.5 ℃
13:00:26	117.7 A	33.0 ℃	85.8 A	33.5 ℃	62.0 A	40.0 ℃	114.2 A	35.5 ℃	93.3 A	38.5 ℃	114.7 A	38.8 ℃
13:05:26	118.1 A	33.0 ℃	86.0 A	33.3 ℃	62.2 A	40.0 ℃	113.7 A	35.5 ℃	93.0 A	38.3 ℃	115.4 A	39.3 ℃
13:10:26	118.3 A	33.0 ℃	86.2 A	33.8 ℃	62.4 A	40.0 ℃	113.9 A	35.3 ℃	93.7 A	38.0 ℃	115.5 A	39.3 ℃
13:15:26	118.7 A	33.3 ℃	85.9 A	34.3 ℃	61.8 A	40.0 ℃	112.9 A	35.3 ℃	93.7 A	38.5 ℃	115.3 A	39.0 ℃
13:20:26	118.5 A	33.3 ℃	86.2 A	34.3 ℃	62.0 A	39.5 ℃	113.9 A	35.3 ℃	93.9 A	38.5 ℃	115.3 A	39.0 ℃
13:25:26	118.5 A	33.3 ℃	86.4 A	34.5 ℃	61.9 A	39.5 ℃	113.3 A	35.0 ℃	93.1 A	38.5 ℃	115.2 A	38.8 ℃
13:30:26	119.1 A	33.3 ℃	86.5 A	34.3 ℃	62.2 A	39.5 ℃	113.1 A	35.3 ℃	93.6 A	38.8 ℃	115.6 A	39.3 ℃
13:35:26	119.1 A	33.5 ℃	86.9 A	34.8 ℃	62.0 A	39.5 ℃	113.8 A	35.5 ℃	92.9 A	38.3 ℃	115.4 A	39.5 ℃
13:40:26	119.1 A	33.8 ℃	86.7 A	34.3 ℃	61.8 A	39.5 ℃	113.8 A	35.5 ℃	93.5 A	38.5 ℃	115.1 A	39.5 ℃
13:45:26	118.6 A	34.0 ℃	87.1 A	34.5 ℃	61.2 A	39.5 ℃	113.2 A	35.0 ℃	93.3 A	38.8 ℃	115.3 A	39.8 ℃
13:50:26	119.1 A	33.5 ℃	86.7 A	34.5 ℃	61.6 A	39.5 ℃	113.2 A	35.3 ℃	93.9 A	39.5 ℃	114.8 A	39.5 ℃
13:55:26	118.9 A	33.5 ℃	86.2 A	33.3 ℃	62.0 A	39.5 ℃	113.3 A	34.8 ℃	93.0 A	39.3 ℃	115.1 A	39.5 ℃
14:00:26	118.4 A	33.8 ℃	86.4 A	33.8 ℃	62.0 A	39.5 ℃	113.2 A	35.0 ℃	92.9 A	39.0 ℃	115.9 A	39.3 ℃
14:05:26	119.1 A	33.8 ℃	86.6 A	34.5 ℃	61.7 A	39.5 ℃	113.4 A	34.8 ℃	94.3 A	39.5 ℃	116.1 A	39.8 ℃
14:10:26	118.7 A	33.5 ℃	86.6 A	35.0 ℃	61.3 A	39.0 ℃	113.4 A	34.8 ℃	94.4 A	40.8 ℃	115.0 A	39.0 ℃
14:15:26	118.5 A	34.3 ℃	85.9 A	34.3 ℃	61.0 A	39.5 ℃	112.9 A	35.0 ℃	93.4 A	40.0 ℃	115.0 A	39.5 ℃
14:20:26	118.8 A	34.3 ℃	86.1 A	34.5 ℃	61.5 A	39.5 ℃	112.9 A	35.0 ℃	92.9 A	38.3 ℃	115.2 A	39.0 ℃
14:25:26	119.5 A	34.0 ℃	86.2 A	35.3 ℃	61.8 A	39.5 ℃	112.8 A	35.3 ℃	93.4 A	39.5 ℃	115.5 A	39.8 ℃
19:30:26	90.6 A	32.0 ℃	57.1 A	33.0 ℃	62.4 A	39.0 ℃	113.4 A	34.0 ℃	89.8 A	35.5 ℃	83.4 A	36.0 ℃
19:35:26	89.4 A	32.0 ℃	84.6 A	32.5 ℃	61.6 A	38.5 ℃	113.1 A	34.0 ℃	89.2 A	35.0 ℃	110.9 A	36.0 ℃
19:40:26	89.7 A	31.5 ℃	84.3 A	32.5 ℃	61.8 A	38.5 ℃	113.4 A	34.3 ℃	89.7 A	35.3 ℃	111.0 A	36.0 ℃
19:45:26	118.8 A	31.8 ℃	84.0 A	32.8 ℃	61.7 A	39.0 ℃	113.0 A	34.3 ℃	89.7 A	35.5 ℃	111.0 A	35.8 ℃
19:50:26	118.9 A	32.3 ℃	85.0 A	32.8 ℃	62.0 A	38.5 ℃	111.9 A	34.3 ℃	89.8 A	35.5 ℃	83.3 A	35.8 ℃
19:55:26	119.9 A	32.5 ℃	57.5 A	33.0 ℃	62.2 A	38.5 ℃	113.2 A	34.3 ℃	90.4 A	35.3 ℃	110.9 A	35.5 ℃
20:00:26	118.6 A	33.0 ℃	84.5 A	32.8 ℃	61.2 A	38.5 ℃	113.1 A	34.3 ℃	89.4 A	35.5 ℃	111.4 A	35.8 ℃
20:05:26	118.6 A	32.5 ℃	84.9 A	32.8 ℃	61.1 A	38.5 ℃	113.6 A	34.3 ℃	90.3 A	35.8 ℃	111.4 A	35.5 ℃
20:10:26	90.3 A	32.8 ℃	84.9 A	32.8 ℃	61.9 A	38.5 ℃	113.3 A	34.0 ℃	90.5 A	36.0 ℃	111.6 A	35.5 ℃
20:15:26	90.9 A	32.3 ℃	85.3 A	32.8 ℃	61.7 A	38.5 ℃	113.1 A	34.3 ℃	90.3 A	35.5 ℃	111.5 A	36.3 ℃
20:20:26	90.9 A	32.0 ℃	85.1 A	32.5 ℃	61.9 A	38.5 ℃	113.4 A	34.0 ℃	89.7 A	35.5 ℃	111.7 A	36.3 ℃
20:25:26	117.6 A	32.3 ℃	84.5 A	32.8 ℃	62.0 A	37.5 ℃	112.6 A	34.5 ℃	89.7 A	34.8 ℃	112.0 A	35.5 ℃
20:30:26	117.4 A	32.0 ℃	84.1 A	32.8 ℃	61.8 A	37.0 ℃	112.9 A	34.5 ℃	90.4 A	35.3 ℃	84.0 A	36.3 ℃
20:35:26	116.9 A	32.0 ℃	84.5 A	33.0 ℃	62.0 A	36.5 ℃	113.3 A	33.8 ℃	90.5 A	35.5 ℃	113.8 A	36.3 ℃
20:40:26	117.3 A	32.3 ℃	84.5 A	32.8 ℃	62.1 A	36.5 ℃	113.7 A	34.0 ℃	90.5 A	35.0 ℃	111.9 A	35.8 ℃
20:45:26	117.5 A	32.0 ℃	84.2 A	33.0 ℃	62.3 A	36.5 ℃	113.2 A	34.0 ℃	91.0 A	35.0 ℃	111.5 A	36.0 ℃
20:50:26	118.4 A	32.0 ℃	84.3 A	32.8 ℃	62.3 A	36.0 ℃	113.0 A	34.0 ℃	90.6 A	35.3 ℃	111.6 A	36.3 ℃
20:55:26	117.4 A	32.8 ℃	84.5 A	33.0 ℃	61.1 A	36.0 ℃	113.1 A	34.0 ℃	89.6 A	35.5 ℃	110.8 A	36.3 ℃
21:00:26	118.1 A	32.0 ℃	84.5 A	33.0 ℃	61.6 A	36.0 ℃	111.8 A	34.0 ℃	89.8 A	36.0 ℃	83.0 A	36.3 ℃
21:05:26	119.3 A	32.0 ℃	84.6 A	32.5 ℃	61.7 A	36.0 ℃	112.3 A	34.0 ℃	89.4 A	35.3 ℃	111.3 A	36.3 ℃
21:10:26	118.8 A	32.5 ℃	84.9 A	32.5 ℃	61.6 A	36.0 ℃	111.7 A	33.5 ℃	90.2 A	35.5 ℃	111.5 A	36.0 ℃
21:15:26	91.1 A	32.8 ℃	84.8 A	33.0 ℃	62.0 A	36.0 ℃	112.8 A	33.8 ℃	90.0 A	35.0 ℃	110.8 A	36.3 ℃
21:20:26	91.1 A	34.0 ℃	113.7 A	33.5 ℃	61.8 A	35.5 ℃	111.9 A	33.8 ℃	90.0 A	35.8 ℃	111.6 A	36.5 ℃
21:25:26	117.9 A	33.0 ℃	84.8 A	33.0 ℃	61.8 A	35.5 ℃	112.5 A	33.8 ℃	90.5 A	35.5 ℃	111.6 A	36.5 ℃

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Table 5.3.2 Adjusted Current Value

Compensation	[redacted]				[redacted]				[redacted]			
Value	CH1		CH2		CH1		CH2		CH1		CH2	
0.0182	Current	Temp.	Current	Temp.	Current	Temp.	Current	Temp.	Current	Temp.	Current	Temp.
11:30:26	118.4 A	33.0 °C	85.6 A	33.5 °C	75.5 A	40.0 °C	107.4 A	35.3 °C	87.5 A	35.3 °C	105.7 A	36.8 °C
11:35:26	117.9 A	33.3 °C	85.8 A	34.3 °C	101.5 A	40.0 °C	110.1 A	35.0 °C	86.7 A	36.0 °C	107.4 A	37.0 °C
11:40:26	117.6 A	33.5 °C	85.4 A	33.5 °C	78.5 A	40.0 °C	109.3 A	35.0 °C	88.0 A	35.5 °C	106.6 A	36.8 °C
11:45:26	117.8 A	33.3 °C	85.6 A	34.0 °C	53.2 A	40.0 °C	109.0 A	35.5 °C	86.1 A	36.8 °C	109.3 A	36.0 °C
11:50:26	117.7 A	33.5 °C	85.7 A	33.8 °C	54.0 A	39.5 °C	109.5 A	35.0 °C	87.1 A	36.8 °C	108.1 A	36.5 °C
11:55:26	90.4 A	33.5 °C	85.9 A	33.5 °C	53.9 A	39.5 °C	107.4 A	35.8 °C	86.7 A	37.0 °C	107.4 A	36.3 °C
12:00:26	90.1 A	33.0 °C	86.0 A	34.0 °C	54.3 A	39.5 °C	108.2 A	36.0 °C	85.5 A	37.0 °C	108.6 A	36.3 °C
12:05:26	118.6 A	32.5 °C	85.5 A	34.0 °C	52.8 A	40.0 °C	109.8 A	35.5 °C	84.5 A	37.0 °C	108.2 A	37.0 °C
12:10:26	118.8 A	32.5 °C	86.3 A	34.3 °C	53.5 A	39.5 °C	108.9 A	36.0 °C	85.1 A	37.3 °C	107.4 A	37.8 °C
12:15:26	118.5 A	32.8 °C	86.0 A	34.3 °C	53.8 A	39.5 °C	109.7 A	35.8 °C	84.2 A	38.0 °C	108.3 A	37.3 °C
12:20:26	118.9 A	32.8 °C	85.9 A	34.3 °C	54.0 A	39.5 °C	111.9 A	35.3 °C	85.6 A	37.5 °C	106.5 A	38.0 °C
12:25:26	118.5 A	33.0 °C	85.9 A	34.0 °C	54.2 A	39.5 °C	111.4 A	35.0 °C	85.8 A	37.3 °C	106.2 A	38.3 °C
12:30:26	118.2 A	33.3 °C	85.9 A	33.3 °C	54.1 A	40.0 °C	108.0 A	35.8 °C	85.1 A	38.0 °C	103.7 A	38.3 °C
12:35:26	90.5 A	33.0 °C	86.3 A	33.5 °C	53.4 A	40.0 °C	107.3 A	36.0 °C	86.1 A	37.0 °C	104.5 A	38.3 °C
12:40:26	90.9 A	32.8 °C	86.5 A	34.0 °C	54.0 A	40.0 °C	109.1 A	36.0 °C	83.6 A	37.8 °C	105.8 A	38.3 °C
12:45:26	118.5 A	33.0 °C	86.1 A	34.0 °C	53.7 A	40.0 °C	109.8 A	35.5 °C	84.8 A	38.3 °C	106.0 A	38.3 °C
12:50:26	118.3 A	32.8 °C	86.4 A	34.3 °C	54.1 A	39.5 °C	111.3 A	35.5 °C	84.8 A	37.5 °C	104.9 A	38.8 °C
12:55:26	118.5 A	33.0 °C	86.1 A	34.0 °C	54.0 A	40.0 °C	109.2 A	36.0 °C	85.3 A	37.8 °C	105.3 A	38.5 °C
13:00:26	117.7 A	33.0 °C	85.8 A	33.5 °C	54.1 A	40.0 °C	110.0 A	35.5 °C	84.0 A	38.5 °C	103.7 A	38.8 °C
13:05:26	118.1 A	33.0 °C	86.0 A	33.3 °C	54.3 A	40.0 °C	109.0 A	35.5 °C	84.1 A	38.3 °C	102.8 A	39.3 °C
13:10:26	118.3 A	33.0 °C	86.2 A	33.8 °C	54.4 A	40.0 °C	110.7 A	35.3 °C	85.1 A	38.0 °C	103.9 A	39.3 °C
13:15:26	118.7 A	33.3 °C	85.9 A	34.3 °C	54.2 A	40.0 °C	110.8 A	35.3 °C	84.7 A	38.5 °C	105.3 A	39.0 °C
13:20:26	118.5 A	33.3 °C	86.2 A	34.3 °C	54.9 A	39.5 °C	111.8 A	35.3 °C	84.9 A	38.5 °C	105.3 A	39.0 °C
13:25:26	118.5 A	33.3 °C	86.4 A	34.5 °C	54.8 A	39.5 °C	112.3 A	35.0 °C	84.2 A	38.5 °C	106.3 A	38.8 °C
13:30:26	119.1 A	33.3 °C	86.5 A	34.3 °C	55.1 A	39.5 °C	111.0 A	35.3 °C	84.2 A	38.8 °C	105.1 A	39.3 °C
13:35:26	119.1 A	33.5 °C	86.9 A	34.8 °C	55.2 A	39.5 °C	112.2 A	35.5 °C	84.9 A	38.3 °C	105.4 A	39.5 °C
13:40:26	119.1 A	33.8 °C	86.7 A	34.3 °C	55.3 A	39.5 °C	111.2 A	35.5 °C	85.4 A	38.5 °C	104.1 A	39.5 °C
13:45:26	118.6 A	34.0 °C	87.1 A	34.5 °C	55.0 A	39.5 °C	112.2 A	35.0 °C	85.2 A	38.8 °C	104.2 A	39.8 °C
13:50:26	119.1 A	33.5 °C	86.7 A	34.5 °C	54.8 A	39.5 °C	111.6 A	35.3 °C	83.6 A	39.5 °C	104.4 A	39.5 °C
13:55:26	118.9 A	33.5 °C	86.2 A	33.3 °C	55.2 A	39.5 °C	110.2 A	34.8 °C	83.3 A	39.3 °C	102.0 A	39.5 °C
14:00:26	118.4 A	33.8 °C	86.4 A	33.8 °C	55.5 A	39.5 °C	110.6 A	35.0 °C	84.0 A	39.0 °C	104.3 A	39.3 °C
14:05:26	119.1 A	33.8 °C	86.6 A	34.5 °C	55.2 A	39.5 °C	112.9 A	34.8 °C	84.4 A	39.5 °C	105.0 A	39.8 °C
14:10:26	118.7 A	33.5 °C	86.6 A	35.0 °C	55.1 A	39.0 °C	113.9 A	34.8 °C	81.9 A	40.8 °C	106.6 A	39.0 °C
14:15:26	118.5 A	34.3 °C	85.9 A	34.3 °C	55.2 A	39.5 °C	111.4 A	35.0 °C	83.6 A	40.0 °C	104.0 A	39.5 °C
14:20:26	118.8 A	34.3 °C	86.1 A	34.5 °C	55.6 A	39.5 °C	111.9 A	35.0 °C	86.1 A	38.3 °C	105.8 A	39.0 °C
14:25:26	119.5 A	34.0 °C	86.2 A	35.3 °C	55.6 A	39.5 °C	112.8 A	35.3 °C	84.0 A	39.5 °C	106.0 A	39.8 °C
19:30:26	90.6 A	32.0 °C	57.1 A	33.0 °C	54.5 A	39.0 °C	111.3 A	34.0 °C	84.0 A	35.5 °C	78.8 A	36.0 °C
19:35:26	89.4 A	32.0 °C	84.6 A	32.5 °C	54.3 A	38.5 °C	110.0 A	34.0 °C	84.3 A	35.0 °C	103.8 A	36.0 °C
19:40:26	89.7 A	31.5 °C	84.3 A	32.5 °C	53.9 A	38.5 °C	109.7 A	34.3 °C	83.6 A	35.3 °C	103.9 A	36.0 °C
19:45:26	118.8 A	31.8 °C	84.0 A	32.8 °C	53.6 A	39.0 °C	109.9 A	34.3 °C	83.5 A	35.5 °C	104.9 A	35.8 °C
19:50:26	118.9 A	32.3 °C	85.0 A	32.8 °C	54.9 A	38.5 °C	108.8 A	34.3 °C	84.4 A	35.5 °C	78.8 A	35.8 °C
19:55:26	119.9 A	32.5 °C	57.5 A	33.0 °C	55.4 A	38.5 °C	110.6 A	34.3 °C	85.8 A	35.3 °C	105.9 A	35.5 °C
20:00:26	118.6 A	33.0 °C	84.5 A	32.8 °C	55.0 A	38.5 °C	110.0 A	34.3 °C	85.3 A	35.5 °C	105.3 A	35.8 °C
20:05:26	118.6 A	32.5 °C	84.9 A	32.8 °C	54.4 A	38.5 °C	110.5 A	34.3 °C	85.0 A	35.8 °C	105.8 A	35.5 °C
20:10:26	90.3 A	32.8 °C	84.9 A	32.8 °C	55.4 A	38.5 °C	110.7 A	34.0 °C	85.1 A	36.0 °C	106.0 A	35.5 °C
20:15:26	90.9 A	32.3 °C	85.3 A	32.8 °C	54.7 A	38.5 °C	110.0 A	34.3 °C	85.0 A	35.5 °C	104.4 A	36.3 °C
20:20:26	90.9 A	32.0 °C	85.1 A	32.5 °C	54.6 A	38.5 °C	110.3 A	34.0 °C	84.0 A	35.5 °C	104.1 A	36.3 °C
20:25:26	117.6 A	32.3 °C	84.5 A	32.8 °C	56.1 A	37.5 °C	109.0 A	34.5 °C	85.6 A	34.8 °C	106.3 A	35.5 °C
20:30:26	117.4 A	32.0 °C	84.1 A	32.8 °C	56.1 A	37.0 °C	109.3 A	34.5 °C	85.0 A	35.3 °C	78.6 A	36.3 °C
20:35:26	116.9 A	32.0 °C	84.5 A	33.0 °C	56.9 A	36.5 °C	111.8 A	33.8 °C	84.7 A	35.5 °C	107.1 A	36.3 °C
20:40:26	117.3 A	32.3 °C	84.5 A	32.8 °C	57.3 A	36.5 °C	111.1 A	34.0 °C	86.0 A	35.0 °C	105.8 A	35.8 °C
20:45:26	117.5 A	32.0 °C	84.2 A	33.0 °C	57.2 A	36.5 °C	111.1 A	34.0 °C	86.0 A	35.0 °C	105.4 A	36.0 °C
20:50:26	118.4 A	32.0 °C	84.3 A	32.8 °C	57.7 A	36.0 °C	110.4 A	34.0 °C	85.2 A	35.3 °C	104.5 A	36.3 °C
20:55:26	117.4 A	32.8 °C	84.5 A	33.0 °C	57.5 A	36.0 °C	111.0 A	34.0 °C	85.1 A	35.5 °C	104.2 A	36.3 °C
21:00:26	118.1 A	32.0 °C	84.5 A	33.0 °C	57.1 A	36.0 °C	109.8 A	34.0 °C	83.3 A	36.0 °C	78.1 A	36.3 °C
21:05:26	119.3 A	32.0 °C	84.6 A	32.5 °C	57.2 A	36.0 °C	109.2 A	34.0 °C	84.1 A	35.3 °C	103.7 A	36.3 °C
21:10:26	118.8 A	32.5 °C	84.9 A	32.5 °C	57.6 A	36.0 °C	109.7 A	33.5 °C	85.3 A	35.5 °C	104.4 A	36.0 °C
21:15:26	91.1 A	32.8 °C	84.8 A	33.0 °C	58.3 A	36.0 °C	111.2 A	33.8 °C	86.3 A	35.0 °C	104.2 A	36.3 °C
21:20:26	91.1 A	34.0 °C	113.7 A	33.5 °C	60.1 A	35.5 °C	111.4 A	33.8 °C	87.1 A	35.8 °C	105.5 A	36.5 °C
21:25:26	117.9 A	33.0 °C	84.8 A	33.0 °C	59.0 A	35.5 °C	111.0 A	33.8 °C	86.3 A	35.5 °C	104.4 A	36.5 °C

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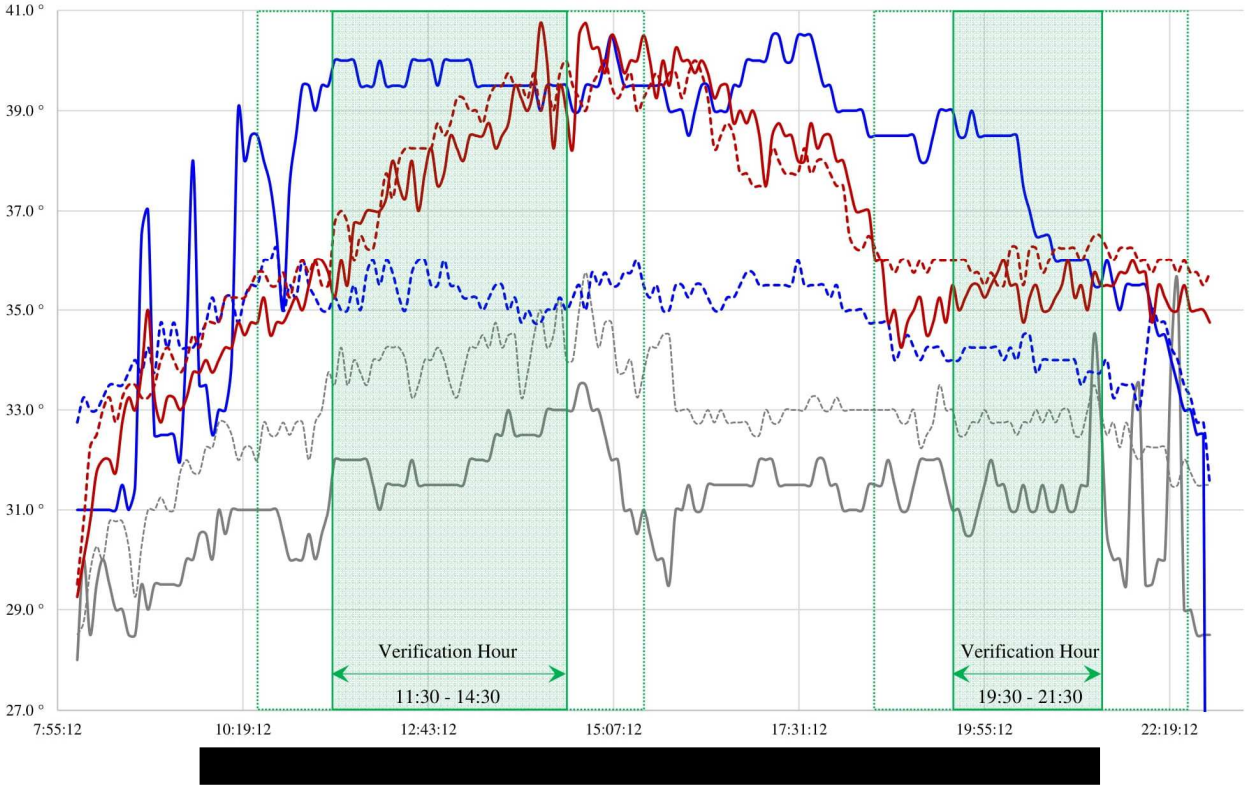

Fig. 5.3.1 Temperature Variation

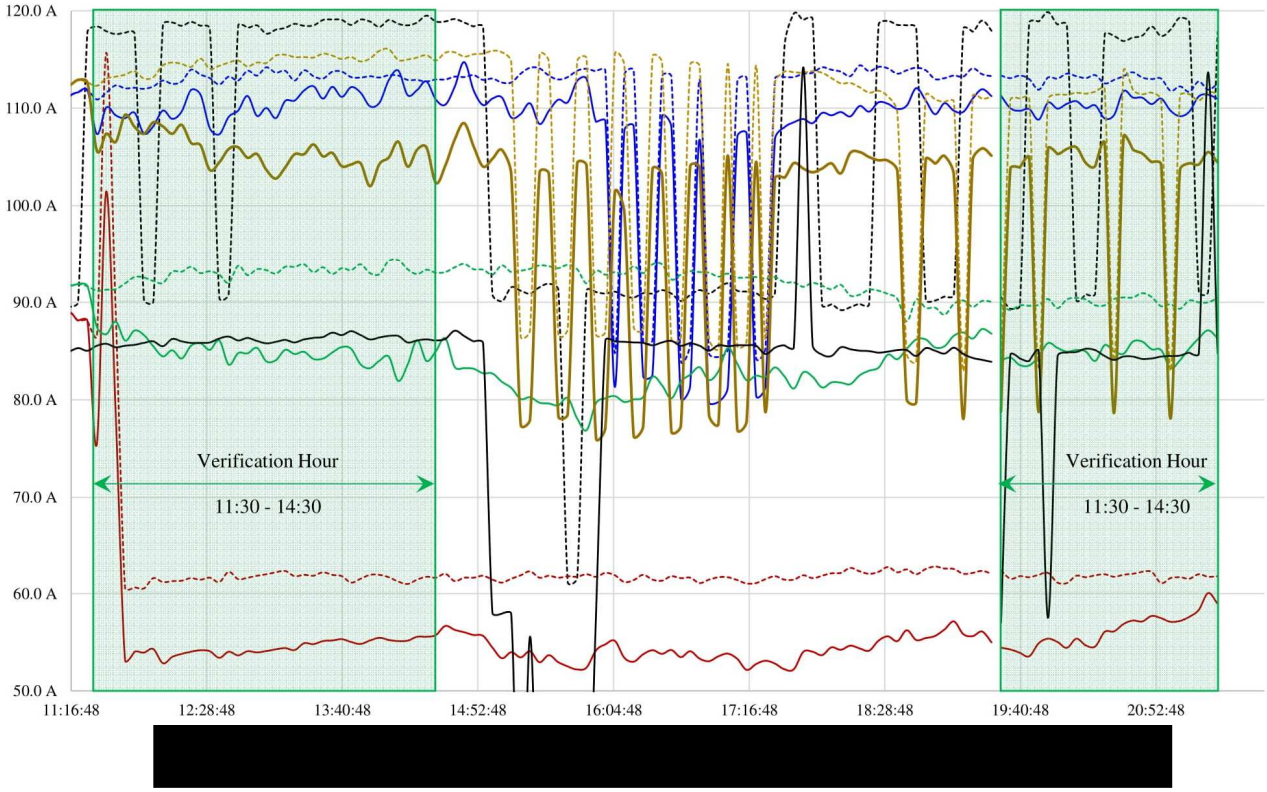

Fig. 5.3.2 Current Value Adjustment

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With reference to variation of intake air temperature[redacted] - Conditions A (hereafter referred to "A") is the lowest on both Chillers. However, the appearance of the variation of current values @Chiller No. 1 has lower current values on [redacted] - Conditions B (hereafter referred to "B") and [redacted] - Conditions C (hereafter referred to "C") compared to A. It can not only be considered because of the affected of the Refrigerant as well as SPACON but the efficiency of the heat load inside of the room.

The chiller intake air temperature at B indicates a special condition. This probably can assume that it is a Monday and there are few people in the building, and the cold air from 1F is flowing into 2F.

Chiller control also presents a different aspect. In A, the compressor of chiller No. 1 is controlled at almost 100% operating state while No. 2 is controlled at 75% operating state, but when Refrigerant or SPACON is used, the compressor of chiller No. 2 is controlled at 100% operating state and the compressor of No. 1 is controlled at 50% and 75% operating state, respectively.

Despite the fact that the temperature is in a high range of the day, the operating status of Chiller No. 2 is controlled during the tenants' lunch break time, and it can be recognized that the indoor heat load is greatly affecting the compressor operation.

The above situation requires consideration of the effect of indoor heat load. Assuming that indoor FCUs and AHUs are operating normally, the current value per unit return chilled water temperature that reflects the indoor heat source situation is calculated and showed Table 5.3.3 and Fig. 5.3.3.

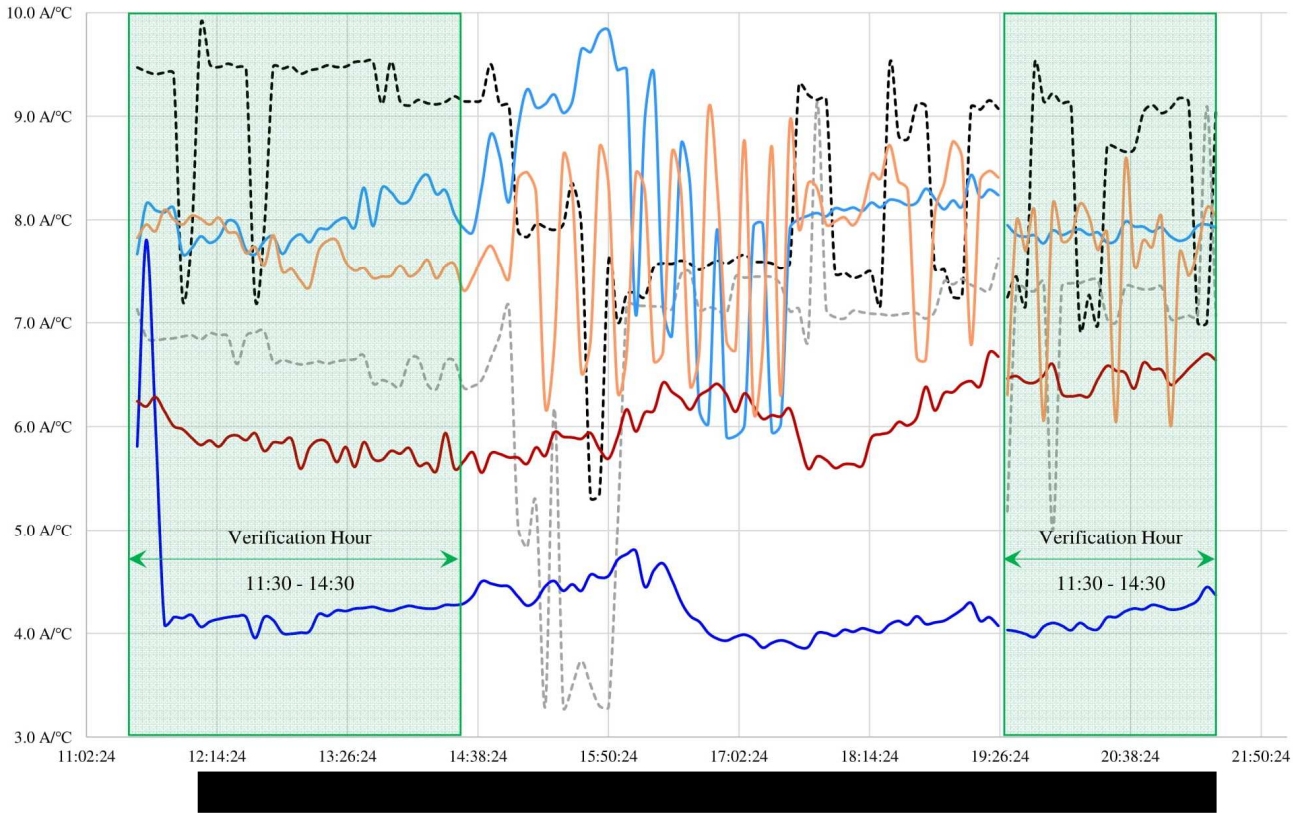

Fig. 5.3.3 Current (A) - Chilled Water (℃) Correlation Chart

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Table 5.3.3 Current (A) – Returned Chilled Water (℃)

	[redacted]																	
	CH1			CH2			CH1			CH2			CH1			CH2		
	Current	C.Temp.	A/℃	Current	C.Temp.	A/℃	Current	C.Temp.	A/℃	Current	C.Temp.	A/℃	Current	C.Temp.	A/℃	Current	C.Temp.	A/℃
11:30:26	118.4 A	12.5 ℃	9.5 A/℃	85.6 A	12.0 ℃	7.1 A/℃	75.5 A	13.0 ℃	5.8 A/℃	107.4 A	14.0 ℃	7.7 A/℃	87.5 A	14.0 ℃	6.2 A/℃	105.7 A	13.5 ℃	7.8 A/℃
11:35:26	117.9 A	12.5 ℃	9.4 A/℃	85.8 A	12.5 ℃	6.9 A/℃	101.5 A	13.0 ℃	7.8 A/℃	110.1 A	13.5 ℃	8.2 A/℃	86.7 A	14.0 ℃	6.2 A/℃	107.4 A	13.5 ℃	8.0 A/℃
11:40:26	117.6 A	12.5 ℃	9.4 A/℃	85.4 A	12.5 ℃	6.8 A/℃	78.5 A	13.0 ℃	6.0 A/℃	109.3 A	13.5 ℃	8.1 A/℃	88.0 A	14.0 ℃	6.3 A/℃	106.6 A	13.5 ℃	7.9 A/℃
11:45:26	117.8 A	12.5 ℃	9.4 A/℃	85.6 A	12.5 ℃	6.8 A/℃	53.2 A	13.0 ℃	4.1 A/℃	109.0 A	13.5 ℃	8.1 A/℃	86.1 A	14.0 ℃	6.1 A/℃	109.3 A	13.5 ℃	8.1 A/℃
11:50:26	117.7 A	12.5 ℃	9.4 A/℃	85.7 A	12.5 ℃	6.9 A/℃	54.0 A	13.0 ℃	4.2 A/℃	109.5 A	13.5 ℃	8.1 A/℃	87.1 A	14.5 ℃	6.0 A/℃	108.1 A	13.5 ℃	8.0 A/℃
11:55:26	90.4 A	12.5 ℃	7.2 A/℃	85.9 A	12.5 ℃	6.9 A/℃	53.9 A	13.0 ℃	4.1 A/℃	107.4 A	14.0 ℃	7.7 A/℃	86.7 A	14.5 ℃	6.0 A/℃	107.4 A	13.5 ℃	8.0 A/℃
12:00:26	90.1 A	11.5 ℃	7.8 A/℃	86.0 A	12.5 ℃	6.9 A/℃	54.3 A	13.0 ℃	4.2 A/℃	108.2 A	14.0 ℃	7.7 A/℃	85.5 A	14.5 ℃	5.9 A/℃	108.6 A	13.5 ℃	8.0 A/℃
12:05:26	118.6 A	12.0 ℃	9.9 A/℃	85.5 A	12.5 ℃	6.8 A/℃	52.8 A	13.0 ℃	4.1 A/℃	109.8 A	14.0 ℃	7.8 A/℃	84.5 A	14.5 ℃	5.8 A/℃	108.2 A	13.5 ℃	8.0 A/℃
12:10:26	118.8 A	12.5 ℃	9.5 A/℃	86.3 A	12.5 ℃	6.9 A/℃	53.5 A	13.0 ℃	4.1 A/℃	108.9 A	14.0 ℃	7.8 A/℃	85.1 A	14.5 ℃	5.9 A/℃	107.4 A	13.5 ℃	8.0 A/℃
12:15:26	118.5 A	12.5 ℃	9.5 A/℃	86.0 A	12.5 ℃	6.9 A/℃	53.8 A	13.0 ℃	4.1 A/℃	109.7 A	14.0 ℃	7.8 A/℃	84.2 A	14.5 ℃	5.8 A/℃	108.3 A	13.5 ℃	8.0 A/℃
12:20:26	118.9 A	12.5 ℃	9.5 A/℃	85.9 A	12.5 ℃	6.9 A/℃	54.0 A	13.0 ℃	4.2 A/℃	111.9 A	14.0 ℃	8.0 A/℃	85.6 A	14.5 ℃	5.9 A/℃	106.5 A	13.5 ℃	7.9 A/℃
12:25:26	118.5 A	12.5 ℃	9.5 A/℃	85.9 A	13.0 ℃	6.6 A/℃	54.2 A	13.0 ℃	4.2 A/℃	111.4 A	14.0 ℃	8.0 A/℃	85.8 A	14.5 ℃	5.9 A/℃	106.2 A	13.5 ℃	7.9 A/℃
12:30:26	118.2 A	12.5 ℃	9.5 A/℃	85.9 A	12.5 ℃	6.9 A/℃	54.1 A	13.0 ℃	4.2 A/℃	108.0 A	14.0 ℃	7.7 A/℃	85.1 A	14.5 ℃	5.9 A/℃	103.7 A	13.5 ℃	7.7 A/℃
12:35:26	90.5 A	12.5 ℃	7.2 A/℃	86.3 A	12.5 ℃	6.9 A/℃	53.4 A	13.5 ℃	4.0 A/℃	107.3 A	14.0 ℃	7.7 A/℃	86.1 A	14.5 ℃	5.9 A/℃	104.5 A	13.5 ℃	7.7 A/℃
12:40:26	90.9 A	11.5 ℃	7.9 A/℃	86.5 A	12.5 ℃	6.9 A/℃	54.0 A	13.0 ℃	4.2 A/℃	109.1 A	14.0 ℃	7.8 A/℃	83.6 A	14.5 ℃	5.8 A/℃	105.8 A	14.0 ℃	7.6 A/℃
12:45:26	118.5 A	12.5 ℃	9.5 A/℃	86.1 A	13.0 ℃	6.6 A/℃	53.7 A	13.0 ℃	4.1 A/℃	109.8 A	14.0 ℃	7.8 A/℃	84.8 A	14.5 ℃	5.8 A/℃	106.0 A	13.5 ℃	7.9 A/℃
12:50:26	118.3 A	12.5 ℃	9.5 A/℃	86.4 A	13.0 ℃	6.6 A/℃	54.1 A	13.5 ℃	4.0 A/℃	111.3 A	14.5 ℃	7.7 A/℃	84.8 A	14.5 ℃	5.8 A/℃	104.9 A	14.0 ℃	7.5 A/℃
12:55:26	118.5 A	12.5 ℃	9.5 A/℃	86.1 A	13.0 ℃	6.6 A/℃	54.0 A	13.5 ℃	4.0 A/℃	109.2 A	14.0 ℃	7.8 A/℃	85.3 A	14.5 ℃	5.9 A/℃	105.3 A	14.0 ℃	7.5 A/℃
13:00:26	117.7 A	12.5 ℃	9.4 A/℃	85.8 A	13.0 ℃	6.6 A/℃	54.1 A	13.5 ℃	4.0 A/℃	110.0 A	14.0 ℃	7.9 A/℃	84.0 A	15.0 ℃	5.6 A/℃	103.7 A	14.0 ℃	7.4 A/℃
13:05:26	118.1 A	12.5 ℃	9.4 A/℃	86.0 A	13.0 ℃	6.6 A/℃	54.3 A	13.5 ℃	4.0 A/℃	109.0 A	14.0 ℃	7.8 A/℃	84.1 A	14.5 ℃	5.8 A/℃	102.8 A	14.0 ℃	7.3 A/℃
13:10:26	118.3 A	12.5 ℃	9.5 A/℃	86.2 A	13.0 ℃	6.6 A/℃	54.4 A	13.0 ℃	4.2 A/℃	110.7 A	14.0 ℃	7.9 A/℃	85.1 A	14.5 ℃	5.9 A/℃	103.9 A	13.5 ℃	7.7 A/℃
13:15:26	118.7 A	12.5 ℃	9.5 A/℃	85.9 A	13.0 ℃	6.6 A/℃	54.2 A	13.0 ℃	4.2 A/℃	110.8 A	14.0 ℃	7.9 A/℃	84.7 A	14.5 ℃	5.8 A/℃	105.3 A	13.5 ℃	7.8 A/℃
13:20:26	118.5 A	12.5 ℃	9.5 A/℃	86.2 A	13.0 ℃	6.6 A/℃	54.9 A	13.0 ℃	4.2 A/℃	111.8 A	14.0 ℃	8.0 A/℃	84.9 A	15.0 ℃	5.7 A/℃	105.3 A	13.5 ℃	7.8 A/℃
13:25:26	118.5 A	12.5 ℃	9.5 A/℃	86.4 A	13.0 ℃	6.6 A/℃	54.8 A	13.0 ℃	4.2 A/℃	112.3 A	14.0 ℃	8.0 A/℃	84.2 A	14.5 ℃	5.8 A/℃	106.3 A	14.0 ℃	7.6 A/℃
13:30:26	119.1 A	12.5 ℃	9.5 A/℃	86.5 A	13.0 ℃	6.7 A/℃	55.1 A	13.0 ℃	4.2 A/℃	111.0 A	14.0 ℃	7.9 A/℃	84.2 A	15.0 ℃	5.6 A/℃	105.1 A	14.0 ℃	7.5 A/℃
13:35:26	119.1 A	12.5 ℃	9.5 A/℃	86.9 A	13.0 ℃	6.7 A/℃	55.2 A	13.0 ℃	4.2 A/℃	112.2 A	13.5 ℃	8.3 A/℃	84.9 A	14.5 ℃	5.9 A/℃	105.4 A	14.0 ℃	7.5 A/℃
13:40:26	119.1 A	12.5 ℃	9.5 A/℃	86.7 A	13.5 ℃	6.4 A/℃	55.3 A	13.0 ℃	4.3 A/℃	111.2 A	14.0 ℃	7.9 A/℃	85.4 A	15.0 ℃	5.7 A/℃	104.1 A	14.0 ℃	7.4 A/℃
13:45:26	118.6 A	13.0 ℃	9.1 A/℃	87.1 A	13.5 ℃	6.4 A/℃	55.0 A	13.0 ℃	4.2 A/℃	112.2 A	13.5 ℃	8.3 A/℃	85.2 A	15.0 ℃	5.7 A/℃	104.2 A	14.0 ℃	7.4 A/℃
13:50:26	119.1 A	12.5 ℃	9.5 A/℃	86.7 A	13.5 ℃	6.4 A/℃	54.8 A	13.0 ℃	4.2 A/℃	111.6 A	13.5 ℃	8.3 A/℃	83.6 A	14.5 ℃	5.8 A/℃	104.4 A	14.0 ℃	7.5 A/℃
13:55:26	118.9 A	13.0 ℃	9.1 A/℃	86.2 A	13.5 ℃	6.4 A/℃	55.2 A	13.0 ℃	4.2 A/℃	110.2 A	13.5 ℃	8.2 A/℃	83.3 A	14.5 ℃	5.7 A/℃	102.0 A	13.5 ℃	7.6 A/℃
14:00:26	118.4 A	13.0 ℃	9.1 A/℃	86.4 A	13.0 ℃	6.6 A/℃	55.5 A	13.0 ℃	4.3 A/℃	110.6 A	13.5 ℃	8.2 A/℃	84.0 A	14.5 ℃	5.8 A/℃	104.3 A	14.0 ℃	7.4 A/℃
14:05:26	119.1 A	13.0 ℃	9.2 A/℃	86.6 A	13.0 ℃	6.7 A/℃	55.2 A	13.0 ℃	4.2 A/℃	112.9 A	13.5 ℃	8.4 A/℃	84.4 A	15.0 ℃	5.6 A/℃	105.0 A	14.0 ℃	7.5 A/℃
14:10:26	118.7 A	13.0 ℃	9.1 A/℃	86.6 A	13.5 ℃	6.4 A/℃	55.1 A	13.0 ℃	4.2 A/℃	113.9 A	13.5 ℃	8.4 A/℃	81.9 A	14.5 ℃	5.7 A/℃	106.6 A	14.0 ℃	7.6 A/℃
14:15:26	118.5 A	13.0 ℃	9.1 A/℃	85.9 A	13.5 ℃	6.4 A/℃	55.2 A	13.0 ℃	4.2 A/℃	111.4 A	13.5 ℃	8.2 A/℃	83.6 A	15.0 ℃	5.6 A/℃	104.0 A	14.0 ℃	7.4 A/℃
14:20:26	118.8 A	13.0 ℃	9.1 A/℃	86.1 A	13.0 ℃	6.6 A/℃	55.6 A	13.0 ℃	4.3 A/℃	111.9 A	13.5 ℃	8.3 A/℃	86.1 A	14.5 ℃	5.9 A/℃	105.8 A	14.0 ℃	7.6 A/℃
14:25:26	119.5 A	13.0 ℃	9.2 A/℃	86.2 A	13.0 ℃	6.6 A/℃	55.6 A	13.0 ℃	4.3 A/℃	112.8 A	14.0 ℃	8.1 A/℃	84.0 A	15.0 ℃	5.6 A/℃	106.0 A	14.0 ℃	7.6 A/℃
14:30:26	118.9 A	13.0 ℃	9.1 A/℃	86.1 A	13.5 ℃	6.4 A/℃	55.8 A	13.0 ℃	4.3 A/℃	110.9 A	14.0 ℃	7.9 A/℃	85.0 A	15.0 ℃	5.7 A/℃	102.4 A	14.0 ℃	7.3 A/℃
14:35:26	118.9 A	13.0 ℃	9.1 A/℃	86.3 A	13.5 ℃	6.4 A/℃	56.7 A	13.0 ℃	4.4 A/℃	110.4 A	14.0 ℃	7.9 A/℃	86.3 A	15.0 ℃	5.8 A/℃	104.1 A	14.0 ℃	7.4 A/℃
14:40:26	119.2 A	13.0 ℃	9.2 A/℃	87.1 A	13.5 ℃	6.5 A/℃	56.3 A	12.5 ℃	4.5 A/℃	112.2 A	13.5 ℃	8.3 A/℃	83.4 A	15.0 ℃	5.6 A/℃	106.8 A	14.0 ℃	7.6 A/℃
14:45:26	118.8 A	12.5 ℃	9.5 A/℃	86.6 A	13.0 ℃	6.7 A/℃	56.0 A	12.5 ℃	4.5 A/℃	114.7 A	13.0 ℃	8.8 A/℃	83.3 A	14.5 ℃	5.7 A/℃	108.5 A	14.0 ℃	7.7 A/℃
14:50:26	118.4 A	13.0 ℃	9.1 A/℃	86.0 A	12.5 ℃	6.9 A/℃	55.8 A	12.5 ℃	4.5 A/℃	111.9 A	13.0 ℃	8.6 A/℃	83.2 A	14.5 ℃	5.7 A/℃	106.1 A	14.0 ℃	7.6 A/℃
14:55:26	118.3 A	13.0 ℃	9.1 A/℃	85.8 A	12.0 ℃	7.2 A/℃	55.7 A	12.5 ℃	4.5 A/℃	110.3 A	13.5 ℃	8.2 A/℃	82.7 A	14.5 ℃	5.7 A/℃	104.0 A	14.0 ℃	7.4 A/℃
19:30:26	90.6 A	12.5 ℃	7.2 A/℃	57.1 A	11.0 ℃	5.2 A/℃	54.5 A	13.5 ℃	4.0 A/℃	111.3 A	14.0 ℃	7.9 A/℃	84.0 A	13.0 ℃	6.5 A/℃	78.8 A	12.5 ℃	6.3 A/℃
19:35:26	89.4 A	12.0 ℃	7.4 A/℃	84.6 A	11.5 ℃	7.4 A/℃	54.3 A	13.5 ℃	4.0 A/℃	110.0 A	14.0 ℃	7.9 A/℃	84.3 A	13.0 ℃	6.5 A/℃	103.8 A	13.0 ℃	8.0 A/℃
19:40:26	89.7 A	12.5 ℃	7.2 A/℃	84.3 A	11.5 ℃	7.3 A/℃	53.9 A	13.5 ℃	4.0 A/℃	109.7 A	14.0 ℃	7.8 A/℃	83.6 A	13.0 ℃	6.4 A/℃	103.9 A	13.5 ℃	7.7 A/℃
19:45:26	118.8 A	12.5 ℃	9.5 A/℃	84.0 A	11.5 ℃	7.3 A/℃	53.6 A	13.5 ℃	4.0 A/℃	109.9 A	14.0 ℃	7.9 A/℃	83.5 A	13.0 ℃	6.4 A/℃	104.9 A	13.0 ℃	8.1 A/℃
19:50:26	118.9 A	13.0 ℃	9.1 A/℃	85.0 A	11.5 ℃	7.4 A/℃	54.9 A	13.5 ℃	4.1 A/℃	108.8 A	14.0 ℃	7.8 A/℃	84.4 A	13.0 ℃	6.5 A/℃	78.8 A	13.0 ℃	6.1 A/℃
19:55:26	119.9 A	13.0 ℃	9.2 A/℃	57.5 A	11.5 ℃	5.0 A/℃	55.4 A	13.5 ℃	4.1 A/℃	110.6 A	14.0 ℃	7.9 A/℃	85.8 A	13.0 ℃	6.6 A/℃	105.9 A	13.0 ℃	8.1 A/℃
20:00:26	118.6 A	13.0 ℃	9.1 A/℃	84.5 A	11.5 ℃	7.3 A/℃	55.0 A	13.5 ℃	4.1 A/℃	110.0 A	14.0 ℃	7.9 A/℃	85.3 A	13.5 ℃	6.3 A/℃	105.3 A	13.5 ℃	7.8 A/℃
20:05:26	118.6 A	13.0 ℃	9.1 A/℃	84.9 A	11.5 ℃	7.4 A/℃	54.4 A	13.5 ℃	4.0 A/℃	110.5 A	14.0 ℃	7.9 A/℃	85.0 A	13.5 ℃	6.3 A/℃	105.8 A	13.5 ℃	7.8 A/℃
20:10:26	90.3 A	13.0 ℃	6.9 A/℃	84.9 A	11.5 ℃	7.4 A/℃	55.4 A	13.5 ℃	4.1 A/℃	110.7 A	14.0 ℃	7.9 A/℃	85.1 A	13.5 ℃	6.3 A/℃	106.0 A	13.0 ℃	8.2 A/℃
20:15:26	90.9 A	12.5 ℃	7.3 A/℃	85.3 A	11.5 ℃	7.4 A/℃	54.7 A	13.5 ℃	4.1 A/℃	110.0 A	14.0 ℃	7.9 A/℃	85.0 A	13.5 ℃	6.3 A/℃	104.4 A	13.0 ℃	8.0 A/℃
20:20:26	90.9 A	13.0 ℃	7.0 A/℃	85.1 A	11.5 ℃	7.4 A/℃	54.6 A	13.5 ℃	4.0 A/℃	110.3 A	14.0 ℃	7.9 A/℃	84.0 A	13.0 ℃	6.5 A/℃	104.1 A	13.5 ℃	7.7 A/℃
20:25:26	117.6 A	13.5 ℃	8.7 A/℃	84.5 A	12.0 ℃	7.0 A/℃	56.1 A	13.5 ℃	4.2 A/℃	109.0 A	14.0 ℃	7.8 A/℃	85.6 A	13.0 ℃	6.6 A/℃	106.3 A	13.5 ℃	7.9 A/℃
20:30:26	117.4 A	13.5 ℃	8.7 A/℃	84.1 A	12.0 ℃	7.0 A/℃	56.1 A	13.5 ℃	4.2 A/℃	109.3 A	14.0 ℃	7.8 A/℃	85.0 A	13.0 ℃	6.5 A/℃	78.6 A	13.0 ℃	6.0 A/℃
20:35:26	116.9 A	13.5 ℃	8.7 A/℃	84.5 A	11.5 ℃	7.3 A/℃	56.9 A	13.5 ℃	4.2 A/℃	111.8 A	14.0 ℃	8.0 A/℃	84.7 A	13.0 ℃	6.5 A/℃	107.1 A	12.5 ℃	8.6 A/℃
20:40:26	117.3 A	13.5 ℃	8.7 A/℃	84.5 A	11.5 ℃	7.3 A/℃	57.3 A	13.5 ℃	4.2 A/℃	111.1 A	14.0 ℃	7.9 A/℃	86.0 A	13.5 ℃	6.4 A/℃	105.8 A	14.0 ℃	7.6 A/℃
20:45:26	117.5 A	13.0 ℃	9.0 A/℃	84.2 A	11.5 ℃	7.3 A/℃	57.2 A	13.5 ℃	4.2 A/℃	111.1 A	14.0 ℃	7.9 A/℃	86.0 A	13.0 ℃	6.6 A/℃	105.4 A	13.5 ℃	7.8 A/℃
20:50:26	118.4 A	13.0 ℃	9.1 A/℃	84.3 A	11.5 ℃	7.3 A/℃	57.7 A	13.5 ℃	4.3 A/℃	110.4 A	14.0 ℃	7.9 A/℃	85.2 A	13.0 ℃	6.6 A/℃	104.5 A	13.5 ℃	7.7 A/℃
20:55:26	117.4 A	13.0 ℃	9.0 A/℃	84.5 A	11.5 ℃	7.3 A/℃	57.5 A	13.5 ℃	4.3 A/℃	111.0 A	14.0 ℃	7.9 A/℃	85.1 A	13.0 ℃	6.5 A/℃	104.2 A	13.0 ℃	8.0 A/℃
21:00:26	118.1 A	13.0 ℃	9.1 A/℃	84.5 A	12.0 ℃	7.0 A/℃	57.1 A	13.5 ℃	4.2 A/℃	109.8 A	14.0 ℃	7.8 A/℃	83.3 A	13.0 ℃	6.4 A/℃	78.1 A	13.0 ℃	6.0 A/℃
21:05:26	119.3 A	13.0 ℃	9.2 A/℃	84.6 A	12.0 ℃	7.0 A/℃	57.2 A	13.5 ℃	4.2 A/℃	109.2 A	14.0 ℃	7.8 A/℃	84.1 A	13.0 ℃	6.5 A/℃	103.7 A	13.5 ℃	7.7 A/℃
21:10:26	118.8 A	13.0 ℃	9.1 A/℃	84.9 A	12.0 ℃	7.1 A/℃	57.6 A	13.5 ℃	4.3 A/℃	109.7 A	14.0 ℃	7.8 A/℃	85.3 A	13.0 ℃	6.6 A/℃	104.4 A	14.0 ℃	7.5 A/℃
21:15:26	91.1 A	13.0 ℃	7.0 A/℃	84.8 A	12.0 ℃	7.1 A/℃	58.3 A	13.5 ℃	4.3 A/℃	111.2 A	14.0 ℃	7.9 A/℃	86.3 A	13.0 ℃	6.6 A/℃	104.2 A	13.5 ℃	7.7 A/℃
21:20:26	91.1 A	13.0 ℃	7.0 A/℃	113.7 A	12.5 ℃	9.1 A/℃	60.1 A	13.5 ℃	4.4 A/℃	111.4 A	14.0 ℃	8.0 A/℃	87.1 A	13.0 ℃	6.7 A/℃	105.5 A	13.0 ℃	8.1 A/℃
21:25:26	117.9 A	13.0 ℃	9.1 A/℃	84.8 A	12.0 ℃	7.1 A/℃	59.0 A	13.5 ℃	4.4 A/℃	111.0 A	14.0 ℃	7.9 A/℃	86.3 A	13.0 ℃	6.6 A/℃	104.4 A	13.0 ℃	8.0 A/℃

Table 5.3.4 Comparison Table

Date	Time	CH1			CH2		
		Current	C.Temp.	A/℃	Current	C.Temp.	A/℃
[redacted]	11:30 - 14:25	115.4 A	12.5 ℃	9.2 A/℃	86.1 A	12.9 ℃	6.7 A/℃
	19:30 - 21:30	108.9 A	13.0 ℃	8.4 A/℃	83.5 A	11.7 ℃	7.1 A/℃
	11:30 - 14:25	57.0 A	13.1 ℃	4.4 A/℃	110.4 A	13.8 ℃	8.0 A/℃
	19:30 - 21:30	56.2 A	13.5 ℃	4.2 A/℃	110.3 A	14.0 ℃	7.9 ℃
	11:30 - 14:25	85.0 A	14.6 ℃	5.8 A/℃	105.7 A	13.7 ℃	7.7 A/℃
	19:30 - 21:30	85.0 A	13.1 ℃	6.5 A/℃	100.6 A	13.2 ℃	7.6 A/℃

Date	Time	CH1			CH2		
		Current	C.Temp.	A/℃	Current	C.Temp.	A/℃
[redacted]	11:30 - 14:25	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	19:30 - 21:30	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	11:30 - 14:25	50.6%	-4.2%	52.5%	-28.2%	-7.4%	-19.2%
	19:30 - 21:30	48.4%	-4.2%	50.4%	-32.1%	-20.0%	-10.2%
	11:30 - 14:25	26.3%	-16.1%	36.5%	-22.7%	-6.7%	-15.0%
	19:30 - 21:30	22.0%	-1.1%	22.7%	-20.4%	-13.4%	-6.3%

	CH1	CH2	Average
B/A	51.5%	-14.7%	**18.4%**
C/A	29.6%	-10.6%	**9.5%**

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Based on the monitoring data by the temperature logger and current logger, the average reduction of consumption for electricity on Chiller No.1 and No.2 would be confirmed as follows.

B / A – **18.4%** - Refrigerant
C / A – **9.5%** - Hybrid System (Refrigerant + SPACON)

We can only set the temperature logger on the surface of the stop valve in line of chilled water pipes and corrected data were adjusted as per the set data only, and the temperature logger would also be sometimes affected by the temperature of the chiller itself. So we assume that the value of the returned chilled water temperature would be varied.

According to the result of the verification above, Conditions B shows a better reduction percentage than Conditions C. But, it would not normally be happened for these facts because the heat dissipation of the refrigerant by SPACON is remarkable, and it is confirmed that the temperature of the refrigerant In and Out of SPACON drops by 5°C to 7°C. Since the pressure in the refrigerant pipe decreases, it is impossible for the power consumption to increase under the same conditions. These are very different from the heat source conditions in the room being compared, and may not be fully reflected in the per-unit return cooling water temperature comparison.

For the reference purpose, as per the test result of the SPACON and Hybrid System verified in the constant-temperature room, the reduction ratio was confirmed as follows.

SPACON – 12.4% (Test by the [redacted] Head Office, Japan)
Refrigerant – 17.4% (National Industrial Research Institute of [redacted], Japan)
Hybrid System – 25% (Industrial Technology Development Institute. Republic of the Philippines)

In this verification, SPACON was installed for Chiller No.2 only. So, the operation of the Chiller No.1 and No.2 influenced each other and the reduction of the electricity consumption was obviously confirmed at Chiller No.1. And, the usage of the electricity by Chiller No.2 was increased.

6. Conclusion of Investigation

Applying our proposed SPACON and Refrigerant (Hybrid System) can reduce the power consumption of Air-Conditioning units by more than **15%** based upon the verification result as well as the test result confirmed in the constant-temperature room.

7. Assumption of Investment-Cost Saving-Pay Back Period

Electricity fee is unexpectedly priced up in Singapore. We, FUKUMITSU Pte., Ltd., would like to suggest applying our Hybrid System for [redacted] as detailed shown in Annex A, which was committed and proven by our investigation for the investment amount, cost-saving amount and depreciation period.

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We sincerely hope that our products can perform a part in contributing to a sustainable society in Singapore.

We would also be more than happy and proud if our eco-friendly products are installed in a historical building owned by PERENNIAL, a leading developer in Singapore.

Thank you very much for your consideration and look forward to hearing your offer soon.

[redacted]

Kenichi FUKUOKA
Director
FUKUMITSU Pte., Ltd.