Hoshino Resorts
Bandaisan Onsen Hotel

March 2025

Report

Hoshino Resorts Bandaisan Onsen Hotel
Verification of the Heat-Shielding Effect of the Heat-Shielding / Thermal-Insulating Film Air

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Verification Study of the Insulation Effect of the "Air" Clear Heat-Shielding and Insulating Film

[Objective]
The purpose of this study was to verify the performance of the “Air” film in reducing the heating load during the winter season.

[Overview]
To verify the film's performance, we measured and compared the electricity consumption at the Hoshino Resorts Bandaisan Onsen Hotel restaurant during two periods: one with the Air film applied to the south-facing window glass, and one without the film.

[Results]

	Average Outdoor Temperature (℃)	Avg. Temp. 1cm from Window (°C) : Baseline	Average AC Outlet Temp. (Window Side) (°C)	Difference in AC Outlet Temp. (vs. 'Without Film') (°C)	AC Operating Time (h)	Operating Time Reduction (%) [(①-②or③)/①]×100
①Without Air Film	**-5.0**	**16.9**	**34.1**	**---**	**451.95**	
②With Air Film	**-6.3**	**17.7**	**33.0**	**1.1**	**370.50**	**18.02**
③Adjusted	**-6.3**	**16.9**	**32.2**	**1.9**	**311.26**	**31.13**

The study confirmed that applying the Air film to the window glass resulted in an approximate 31.1% reduction in electricity consumption during the winter.

[Conclusion]
Application of the “Air” film to windows was confirmed to enhance heat-shielding performance and reduce the air conditioning power consumption required for summer cooling by 28.1%.

[Analysis]

1. Comparison of Power Consumption

Excluding the days of film application and removal, the power consumption duration was 451 hours and 57 minutes during the period without the Air film, and 370 hours and 30 minutes after the Air film was applied, representing an 18.0% reduction.

	Average Outside Temp. (°C)	Avg. Temp. 1cm from Window (°C)	Avg. AC Outlet Temp. (Window Side) (°C)	Temp. Diff. (°C)	Avg. Temp. near Wall (Corridor Side) (°C)	Avg. AC Outlet Temp. (Corridor Side) (°C)	Temp. Diff. (°C)	AC Operating Time (h)	AC Operating Time Reduction (%) [(①-②)/①]×100
① Without Air Film	**-5.0**	**16.9**	**34.1**	**17.2**	**23.9**	**33.3**	**9.4**	**451.95**	
② With Air Film	**-6.3**	**17.7**	**33.0**	**15.3**	**23.5**	**32.3**	**8.8**	**370.50**	**18.02**

Regarding temperature distribution: During the period without the Air film, the average temperature 1cm from the window was 16.9°C, and the air conditioner's average outlet temperature (window side) was 34.1°C, with a difference of 17.2°C. After the Air film was applied, the air conditioner's average outlet temperature (window side) was 33.0°C, and the average temperature 1cm from the window was 17.7°C. Applying the Air film resulted in a 1.1°C decrease in the air conditioner's average outlet temperature (window side) and a 0.8°C increase in the average temperature 1cm from the window.
Accordingly, holding the air conditioner’s average outlet temperature on the window side at the post-film value, we determine what the temperature 1cm from the window would be in the no-film case, in order to evaluate the reduction in power consumption.
Note that this air conditioner turns on at 25°C and off at 35°C; 33.0°C is not its setpoint temperature. Instead, the air conditioner's outlet temperature decreases when its operating time is reduced.
The heat-transfer relation in the room is given by $q = \alpha (t_i - t_1) A$.
q: heat-transfer rate (W)
α: surface heat-transfer coefficient [W/(m²·K)]
t_i: heat-source temperature (K)
t_1: window-surface temperature (K)
A: window area (m²)
Because the same room is used, the surface heat-transfer coefficients toward the window side and toward the corridor side can be taken as equal. That is, under the same outdoor conditions, when the heat-source temperature changes, the ratios of temperature change between the heat source and the corridor side, and between the heat source and the window side, are proportional.
When calculated using the proportion 17.2 : 9.4 = X : 8.8, which yields X = 16.1, the temperature difference between the air conditioner's average outlet temperature (window side) and the temperature 1cm from the window, without the Air film, would be 16.1°C. This would imply a temperature of 16.9°C at 1cm from the window. However, the actual measured value was 17.7°C.
From this result, it was confirmed that applying the Air film has the effect of raising the temperature 1cm from the window surface by 0.8°C. In other words, using the heat flow from the window glass as a reference, to maintain the temperature 1cm from the window at 16.9°C in the no-film condition, it is understood that the air conditioner's average outlet temperature (window side) should be set to 32.2°C, which is 0.8°C lower than 33.0°C.

Next, we will determine the power consumption when the air conditioner's average outlet temperature (window-facing side) is set to 32.2°C.

	Average Outside Temp. (°C)	Avg. Temp. 1cm from Window (°C) : Baseline	Average AC Outlet Temp. (Window Side) (°C)	Difference in AC Outlet Temp. (vs. 'Without Film') (°C)	AC Operating Time (h)	Operating Time Reduction (%) [(①-②or③)/①]×100
① Without Air Film	**-5.0**	**16.9**	**34.1**	**---**	**451.95**	
② With Air Film	**-6.3**	**17.7**	**33.0**	**1.1**	**370.50**	**18.02**
③ Corrected	**-6.3**	**16.9**	**32.2**	**1.9**	**311.26**	**31.13**

When the air conditioner’s average outlet temperature on the window side is lowered from 34.1°C to 32.2°C, the reduction is calculated as follows. Using proportionality, 1.1 : 81.45 = 1.9 : X, we obtain X = 140.69 hours of reduction. Subtracting this from the no-film baseline operating time of 451.95 hours gives a predicted operating time of 311.26 hours. This corresponds to a 31.13% reduction ((140.69 ÷ 451.95) × 100).

* In these measurements, the outdoor air temperature during the with-film period was 1.3°C lower than during the no-film period; in this analysis it was treated as reference data.

Experiment Details and Results

1. Measurement Location

Hoshino Resorts Bandaisan Onsen Hotel – Restaurant, 6838-68 Sarashina Shimizudaira, Bandai Town, Yama District, Fukushima Prefecture

Window orientation: South, 13.8 m²
Windowglass: FL transparent glass Floor
Floor area: 76 m²

2. Measurement Dates

Period with Film Applied: (Measurements taken 24 hours a day)
- First Period: December 30th, 2024 – January 12th, 2025
- Second Period: January 27th, 2025 – February 9th, 2025

Period Without Film: (Measurements taken 24 hours a day)
- First Period: December 23rd, 2024 – December 29th, 2024
- Second Period: January 13th, 2025 – January 26th, 2025
- Third Period: February 10th, 2025 – February 16th, 2025

3. Measurement Instruments

3-1 Thermocouple Automatic Recording Thermometer

Thermocouple: K-type, 0.1 mm **Logger:** HIOKI Temperature Logger LR5051, 2 channels

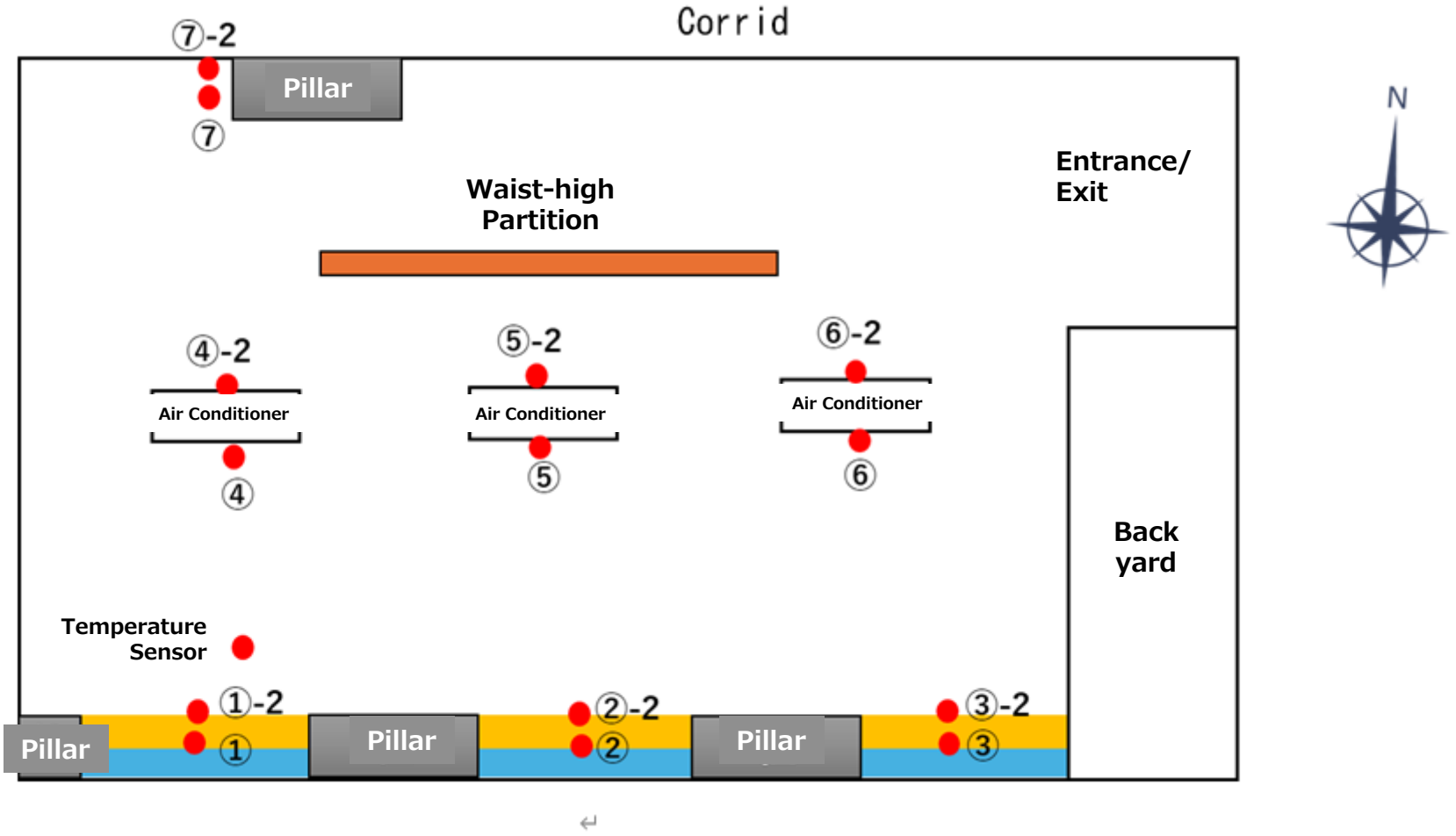
* 1cm from the window surface (3 locations), 5 cm from the window surface (3 locations), AC unit air outlet temperature on the window side (3 locations), AC unit air outlet temperature on the corridor side (3 locations), and temperature near the wall (2 locations)

3-2 Measurement Conditions

a. Indoor Conditions: The heating system was in use.
b. AC Unit Settings: Standard operating settings.
c. External Weather Conditions: Data for the Washikura area, sourced from the official observation log of the Fukushima Local Meteorological Observatory (Tokyo District), was used.

Overall View of the Building

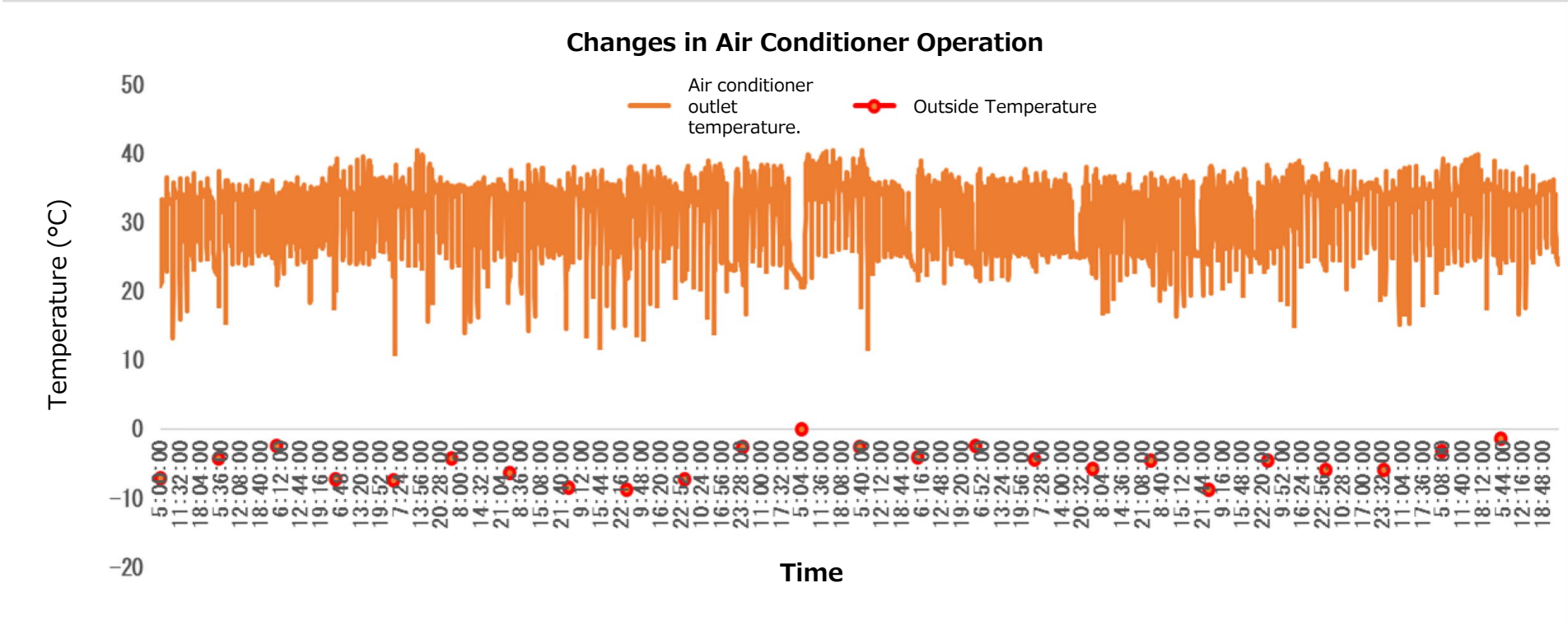
Layout



Temperature at 1 cm and 5 cm from the window surface (2 points each): glass side Air conditioner outlet (2 points each)
Temperature near walls (2 points)

Data

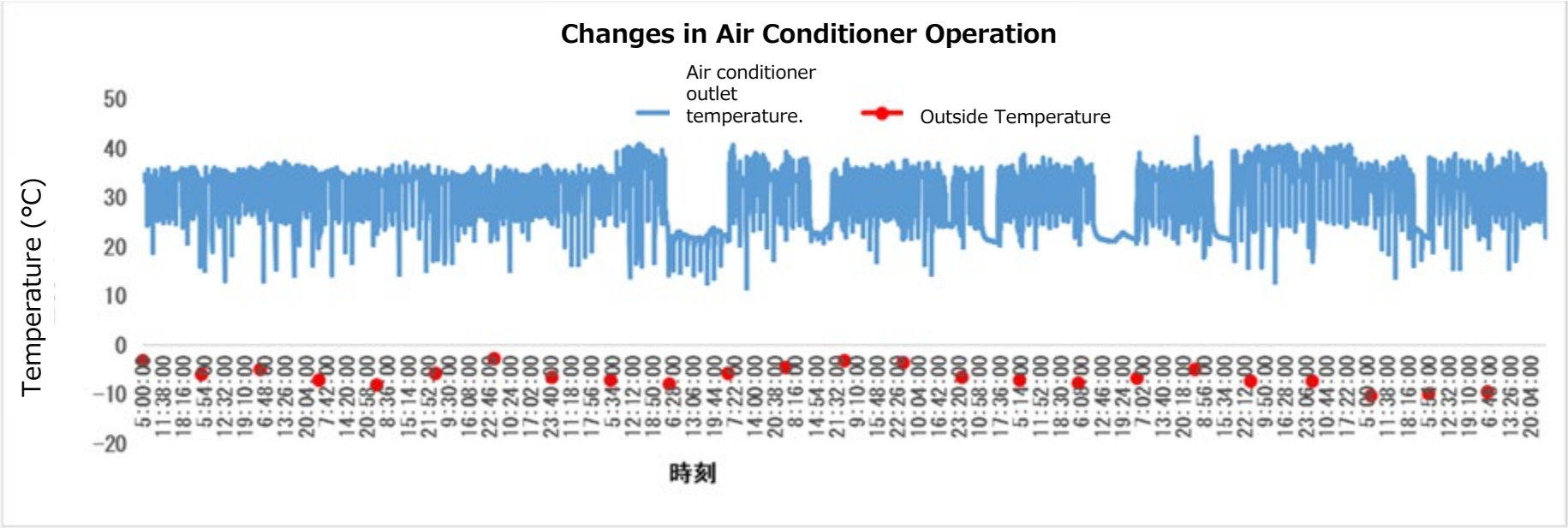
Without Air Film



The AC unit stopped operating for approximately 4 hours, but only when the outside temperature was 0°C or higher (0.1°C).

Data

With Air Film

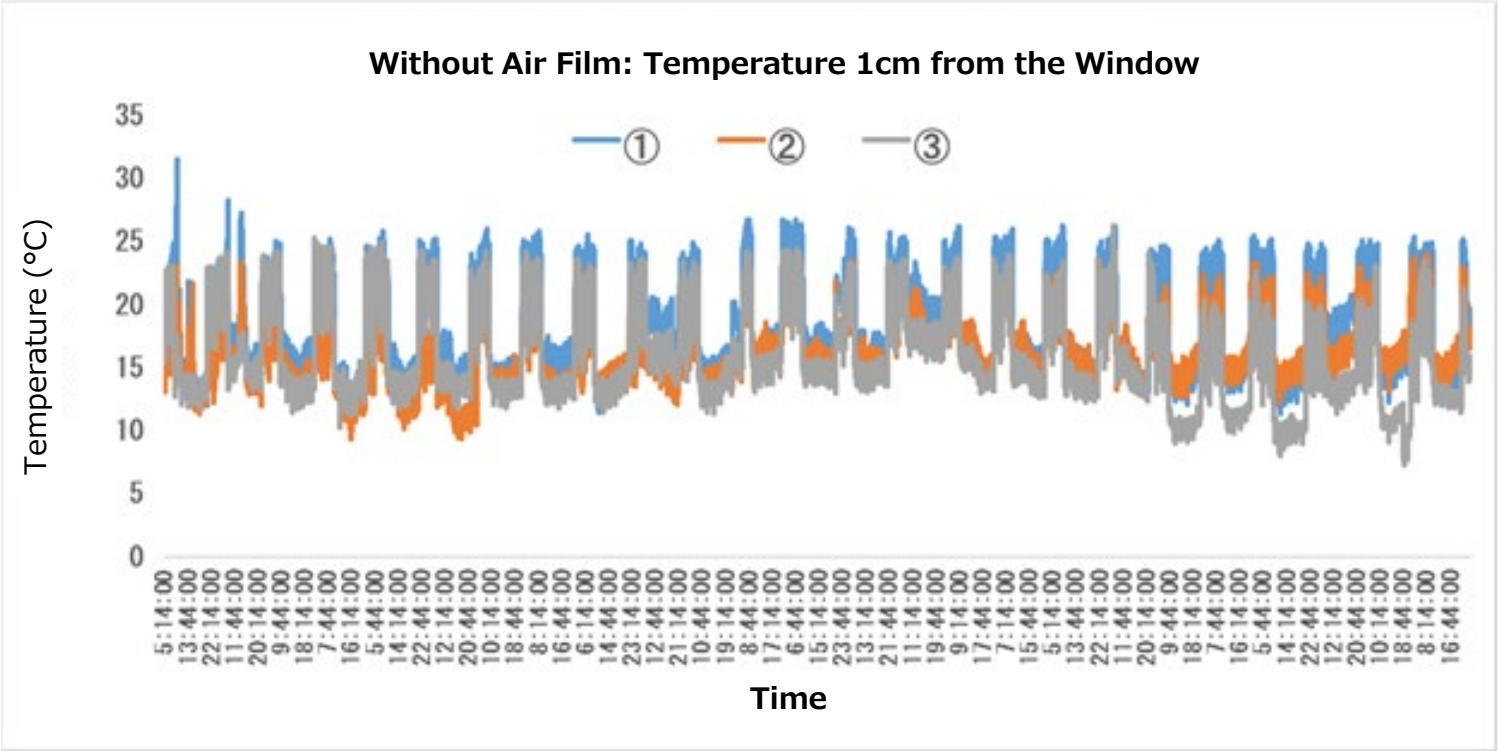


Time

The AC unit stopped operating when the outside temperature rose to -4°C or higher.

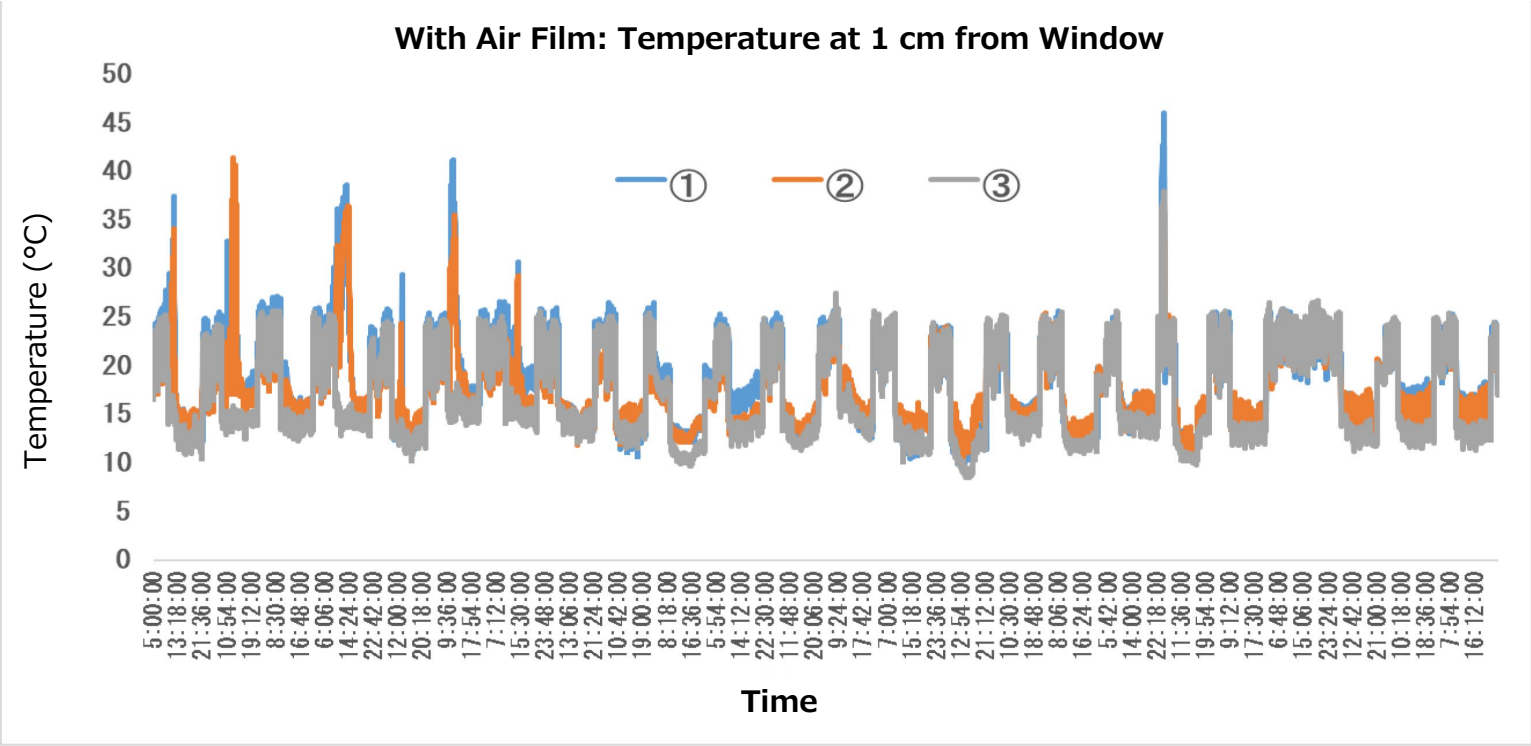
Original data

1) Without Air Film: Temperature 1cm from the Window



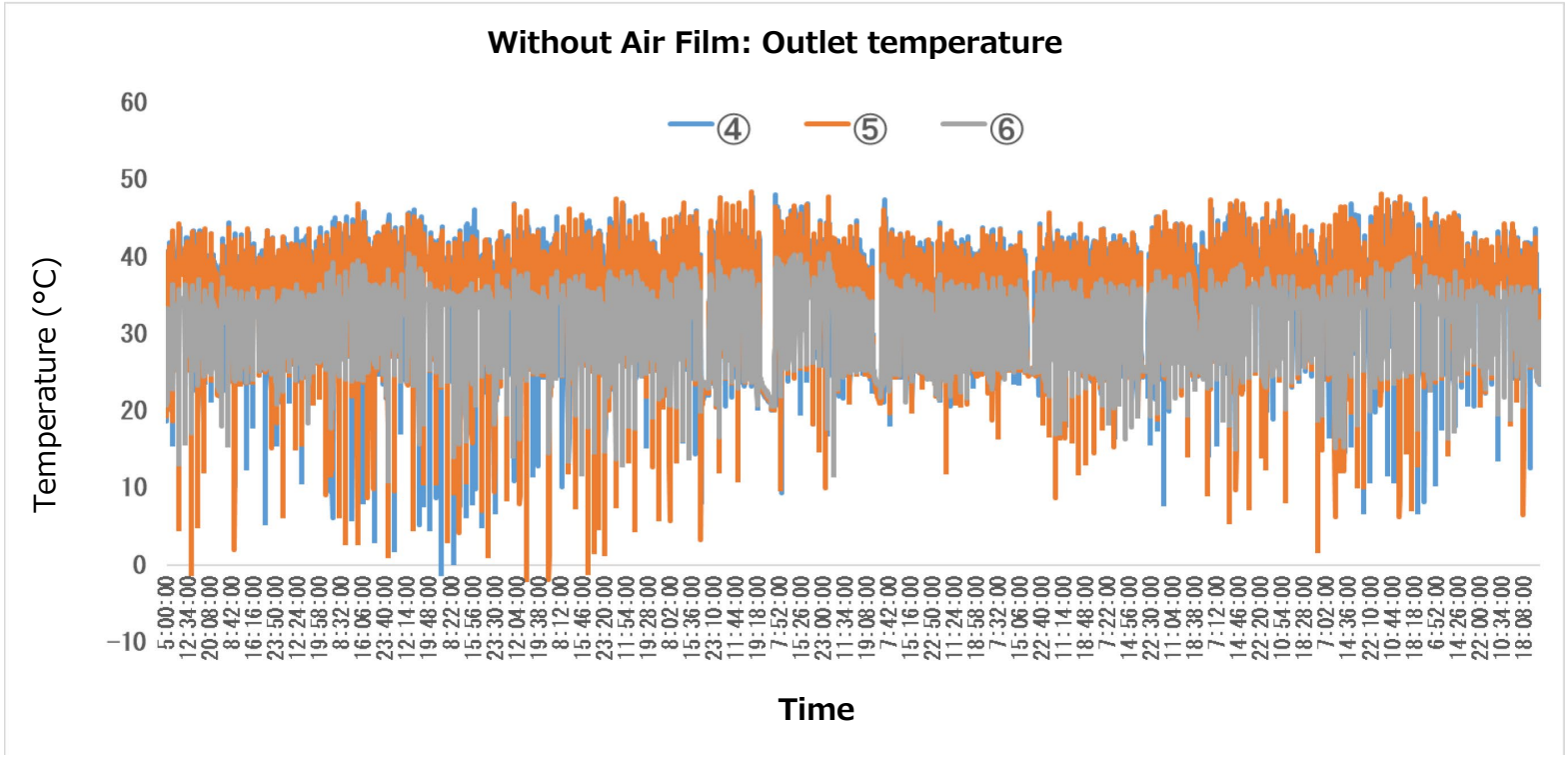
The average temperature 1cm from the window was 16.9°C.

2) With Air Film: Temperature 1cm from the Window



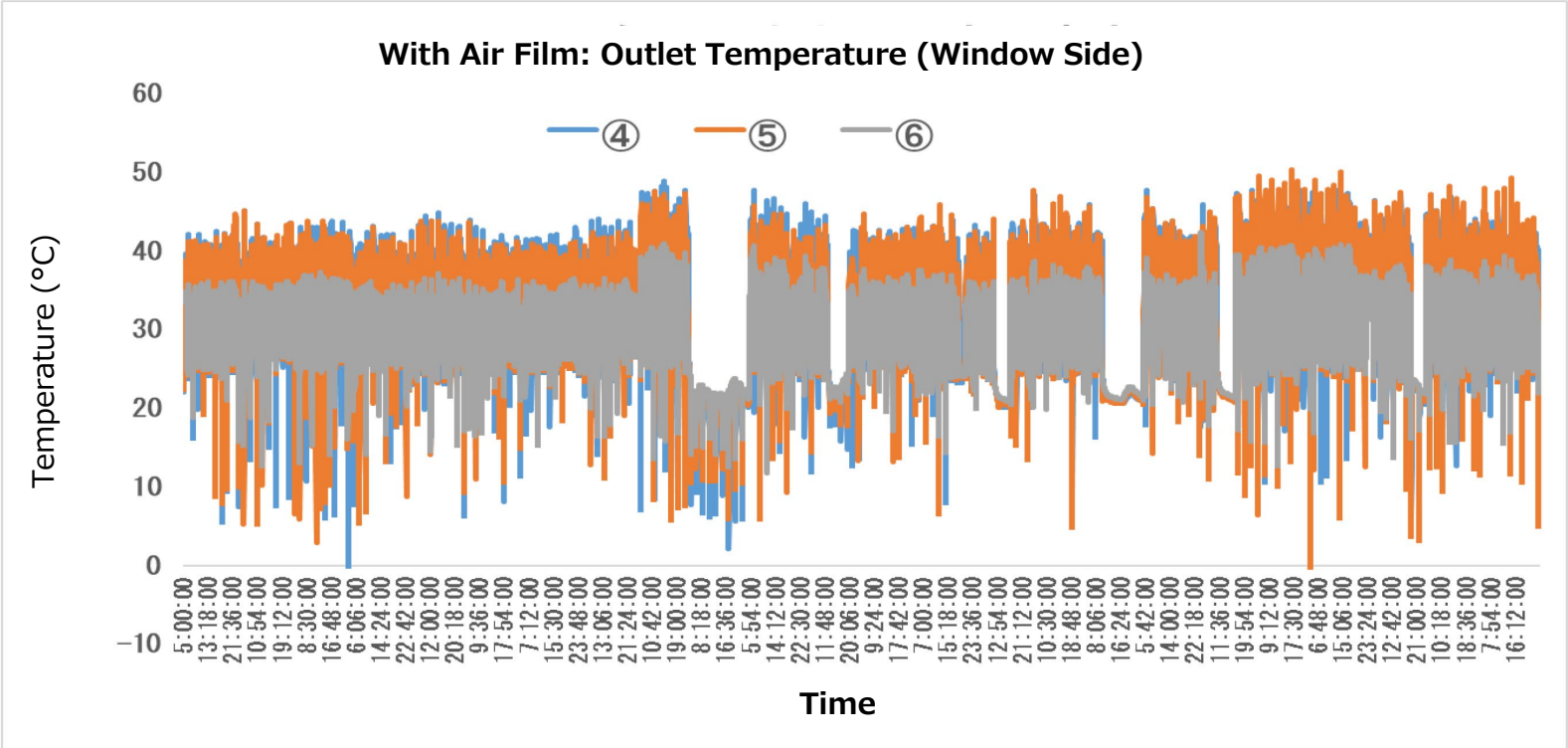
The average temperature 1cm from the window was 17.7°C, which was 0.8°C higher than the measurement without the Air film.

3) Without Air Film: Outlet Temperature (Window Side)



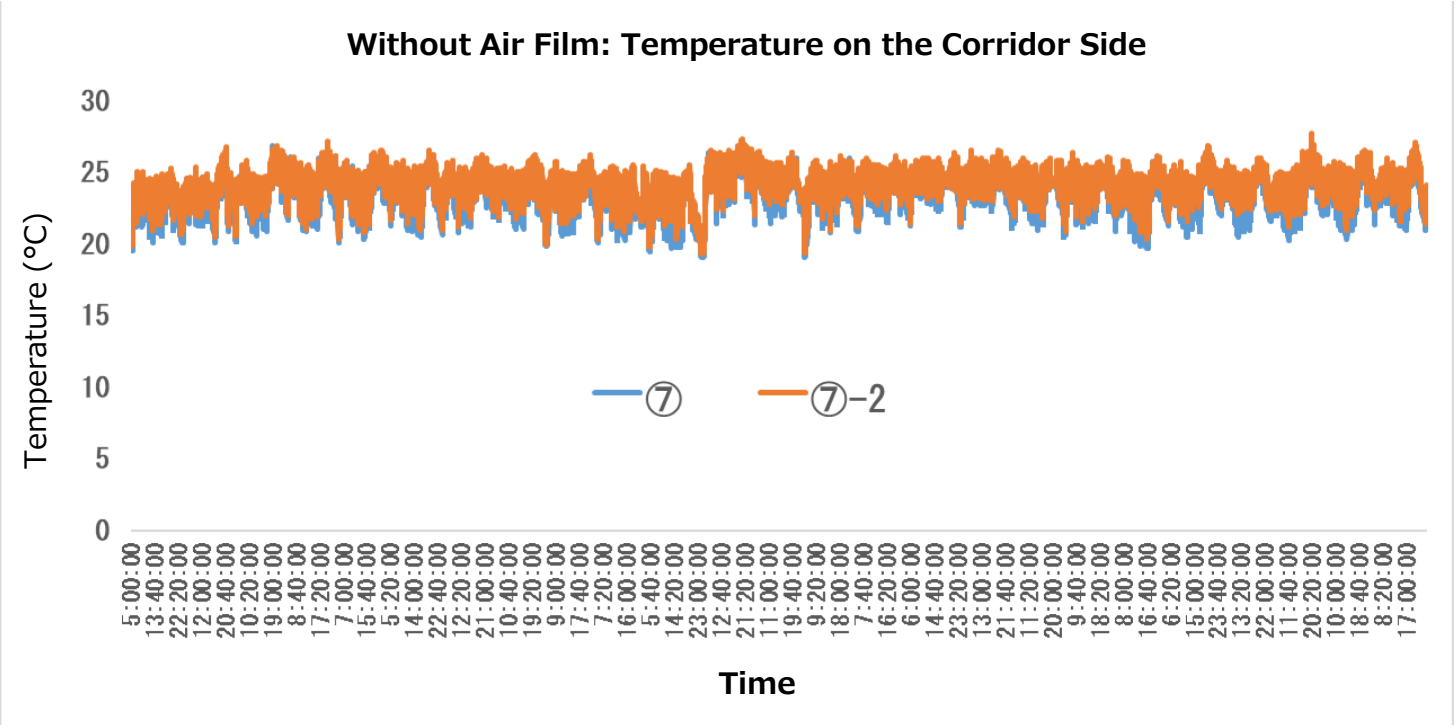
The graph shows that all three AC units were operating simultaneously.
The average outlet temperature was 34.1°C, and the temperature 1cm from the window was 16.9°C, resulting in a difference of 17.2°C.

4) With Air Film: Outlet Temperature (Window Side)



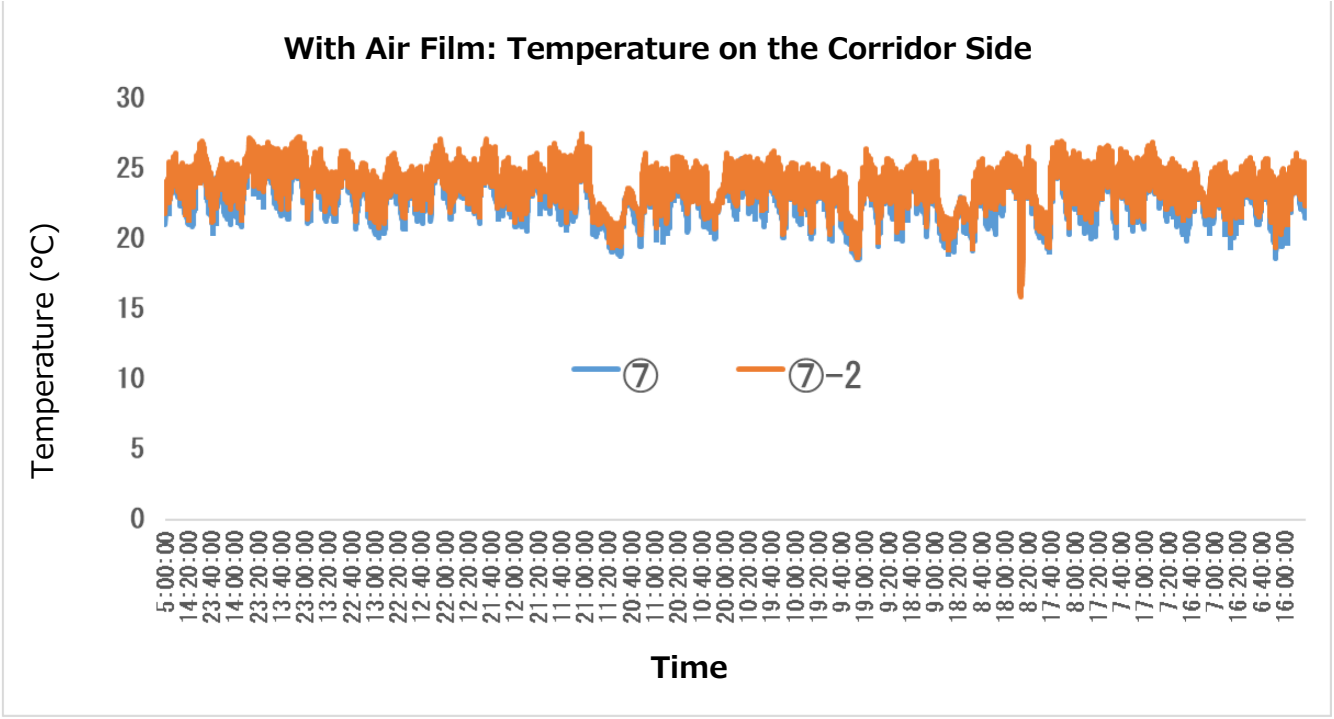
The graph shows that all three AC units were operating simultaneously.
The downtime was longer compared to the period without the film, and the average outlet temperature was 33.0°C, a decrease of 1.1°C.
The temperature difference between the outlet and the point 1cm from the window was 15.3°C, which is 1.9°C smaller than the difference recorded without the film.

5) Without Air Film: Temperature on the Corridor Side



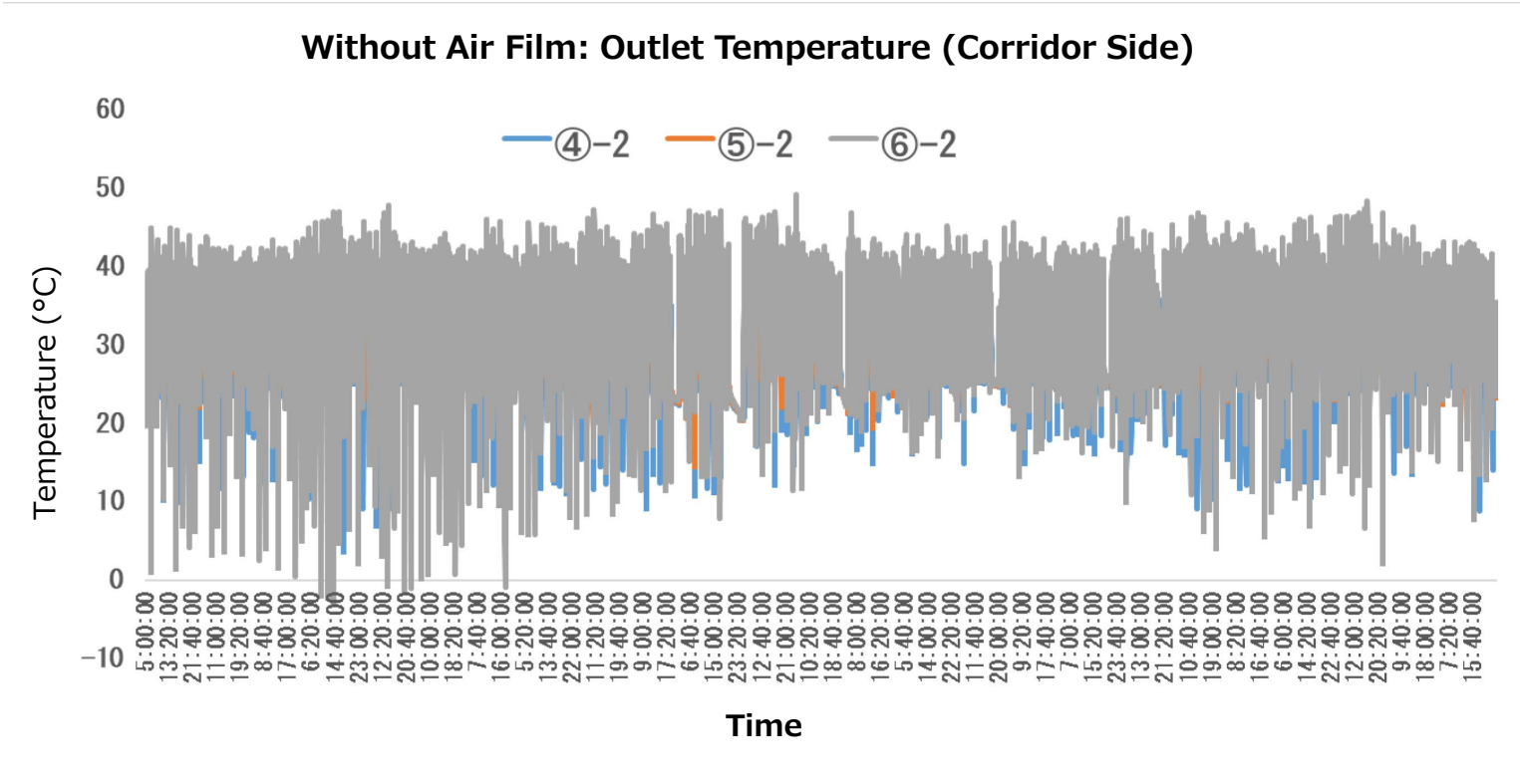
The average temperature was 23.9°C.

6) With Air Film: Temperature on the Corridor Side



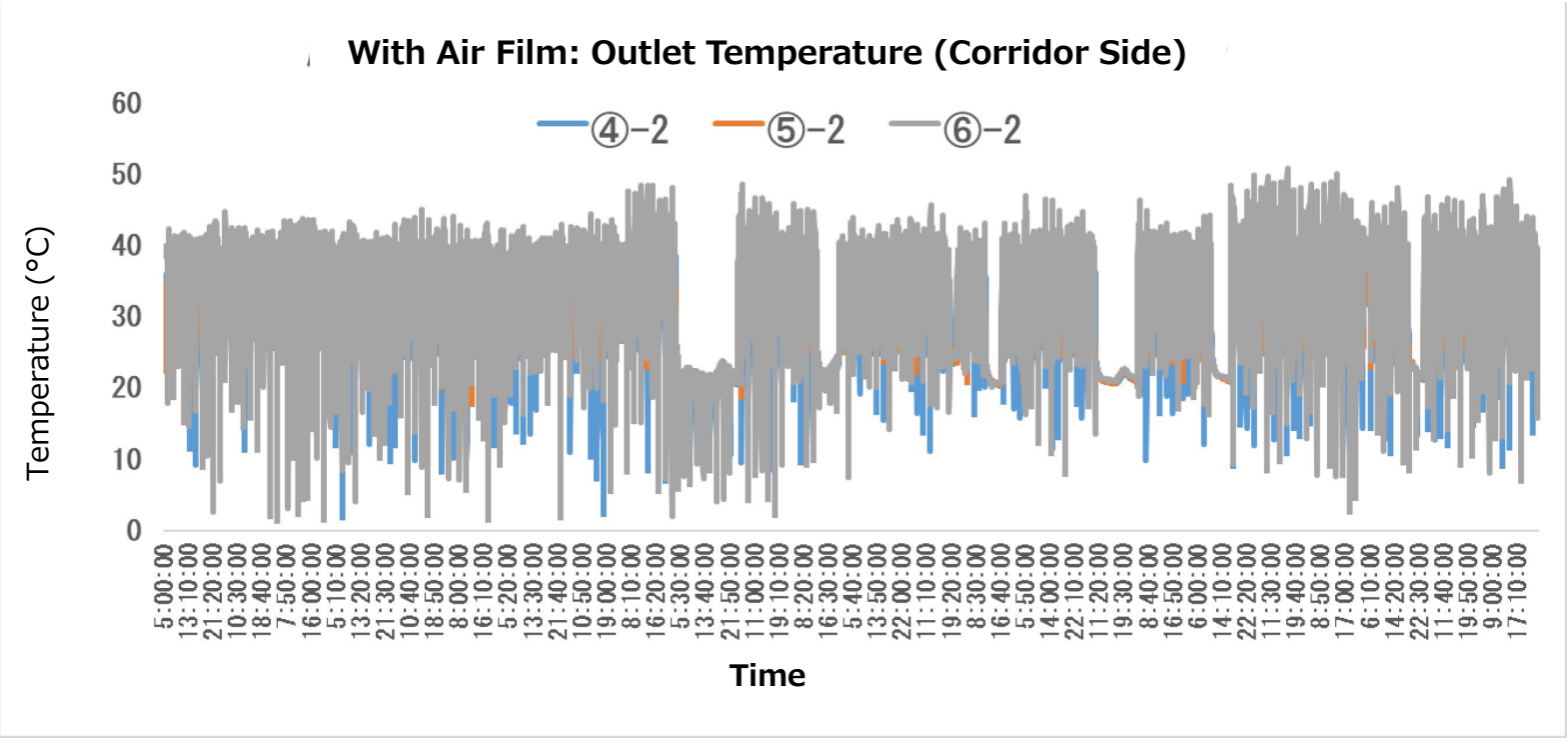
The average temperature was 23.5°C, which was 0.4°C lower than the measurement without the Air film (23.9°C).

7) Without Air Film: Outlet Temperature (Corridor Side)



The graph shows that all three AC units were operating simultaneously.
The average temperature was 33.3°C, and the difference from the corridor side temperature was 9.4°C.

8) With Air Film: Outlet Temperature (Corridor Side)



The graph shows that all three AC units were operating simultaneously.
The downtime was longer compared to the period without the film, and the average outlet temperature was 32.3°C, a decrease of 0.7°C.
The difference from the corridor side temperature was 8.8°C, which is 0.6°C smaller than the difference recorded without the film.