

Research on annual energy consumption of packaged air-conditioning units

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June 4, 2004 in Yokohama, Japan.

Research Purpose

Assessment of power consumption of packaged air-conditioning units

JRA4048:2001 by JRAIA is used to calculate the annual electrical power consumption



● To examine the reliability of the JRA standard . . .

- ✦ Measurement of three subjects (A, B, C)
- ✦ Calculation with JRA4048 standard
- ✦ Comparison between calculated and measured values

Performance measurements of three PAC units

Subjects of measurement:

- ◆ Packaged air-conditioning units

- A ··· Constant speed (Ceiling-suspended type)

<Rated cooling capacity 12.5kW, COP=2.63, R22>

- B ··· Inverter-equipped (Ceiling-mounted cassette type)

<Rated cooling capacity 10.0kW, COP=4.52, R407C>

- C ··· Inverter-equipped (Ceiling-mounted cassette type)



Test Purposes

- The reliability of JRA4048:2001 「Method of assessing seasonal power consumption (期間消費電力量算出方法)」
- Measurement of running performance under part load and intermittent running conditions
- Measurement of performance degradation coefficient (C_D)

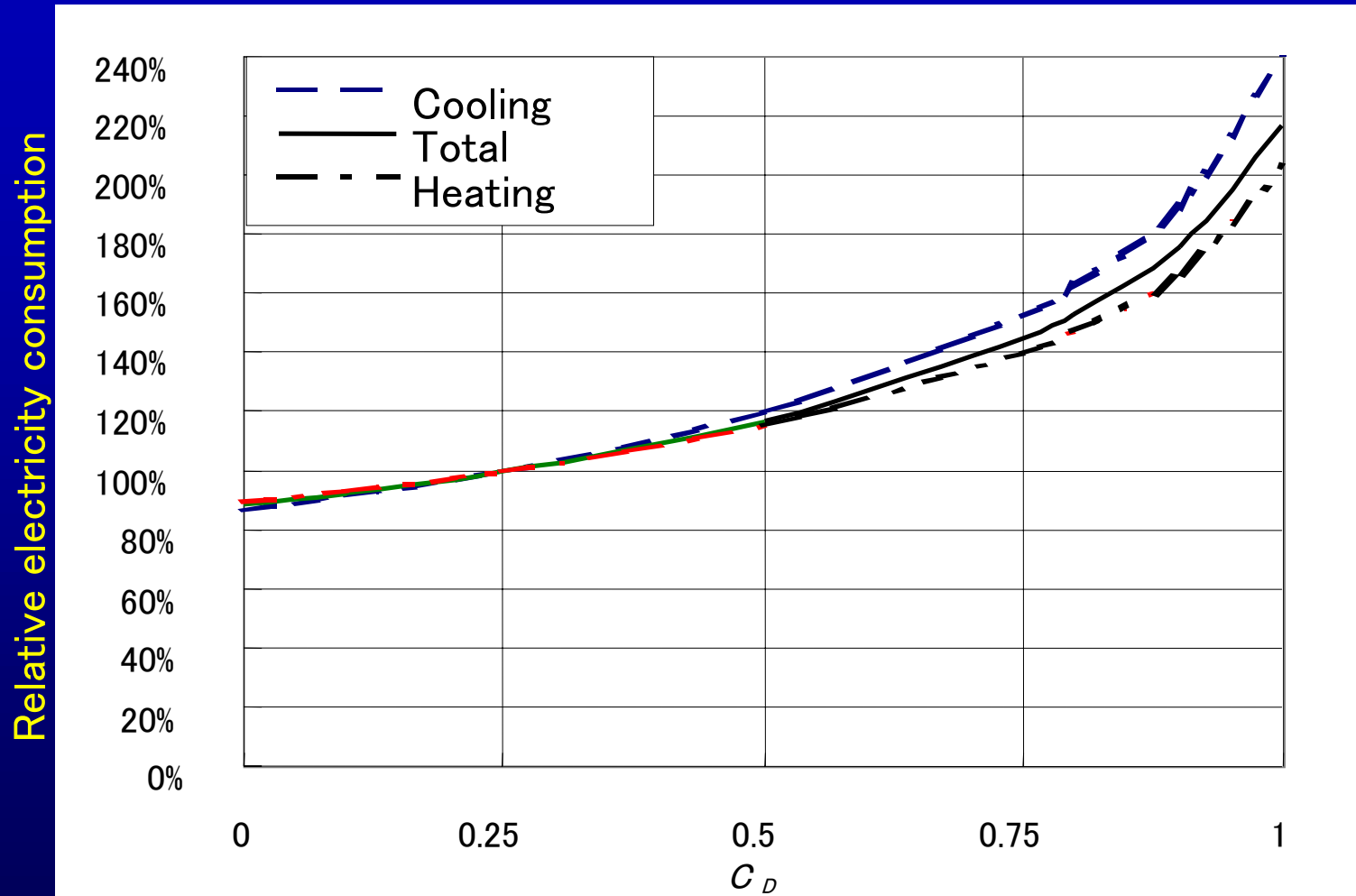
$$C_D = \frac{1 - COP_{c(cyc)} / COP_{c(dry)}}{1 - Q_{c(cyc)} / Q_{c(dry)}}$$

JRA standard $C_D=0.25=const$

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?????

Effect of C_D values: constant speed

$C_D=0.25$ at 100% of seasonal power consumption

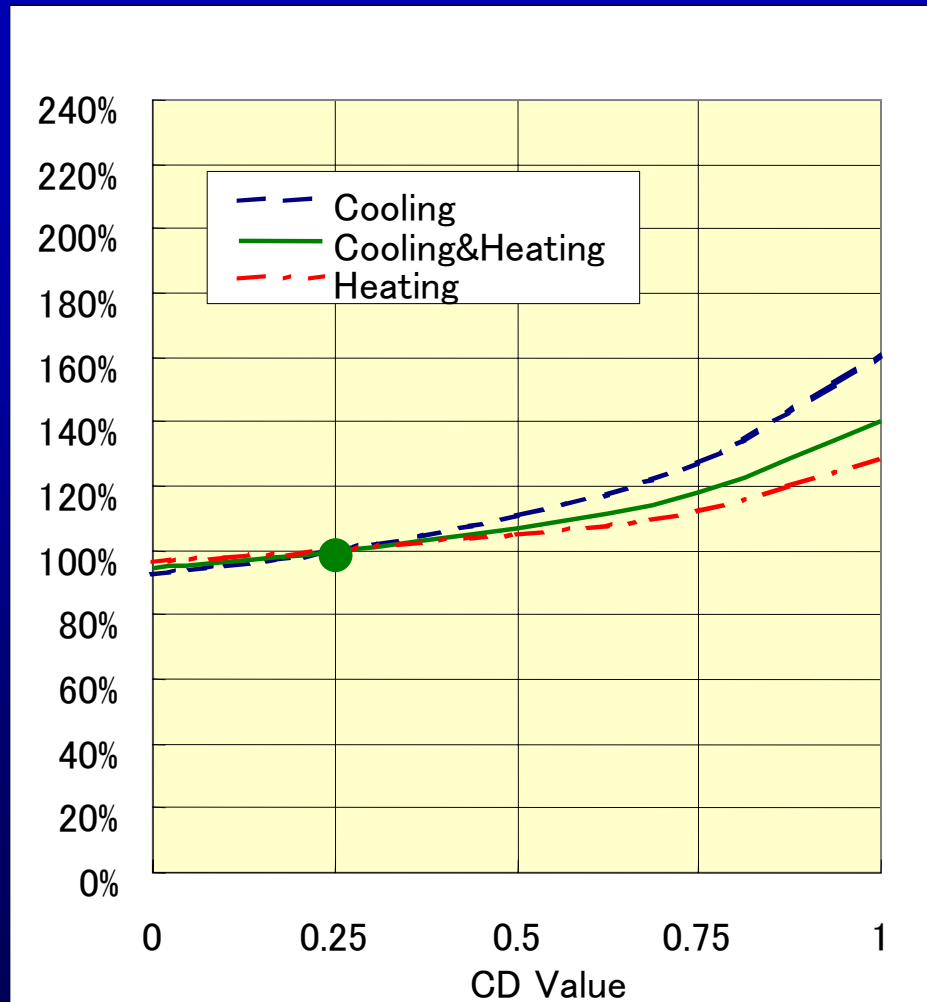


$C_D=0.25$.

Calculated

Effect of C_D values: inverter-installed

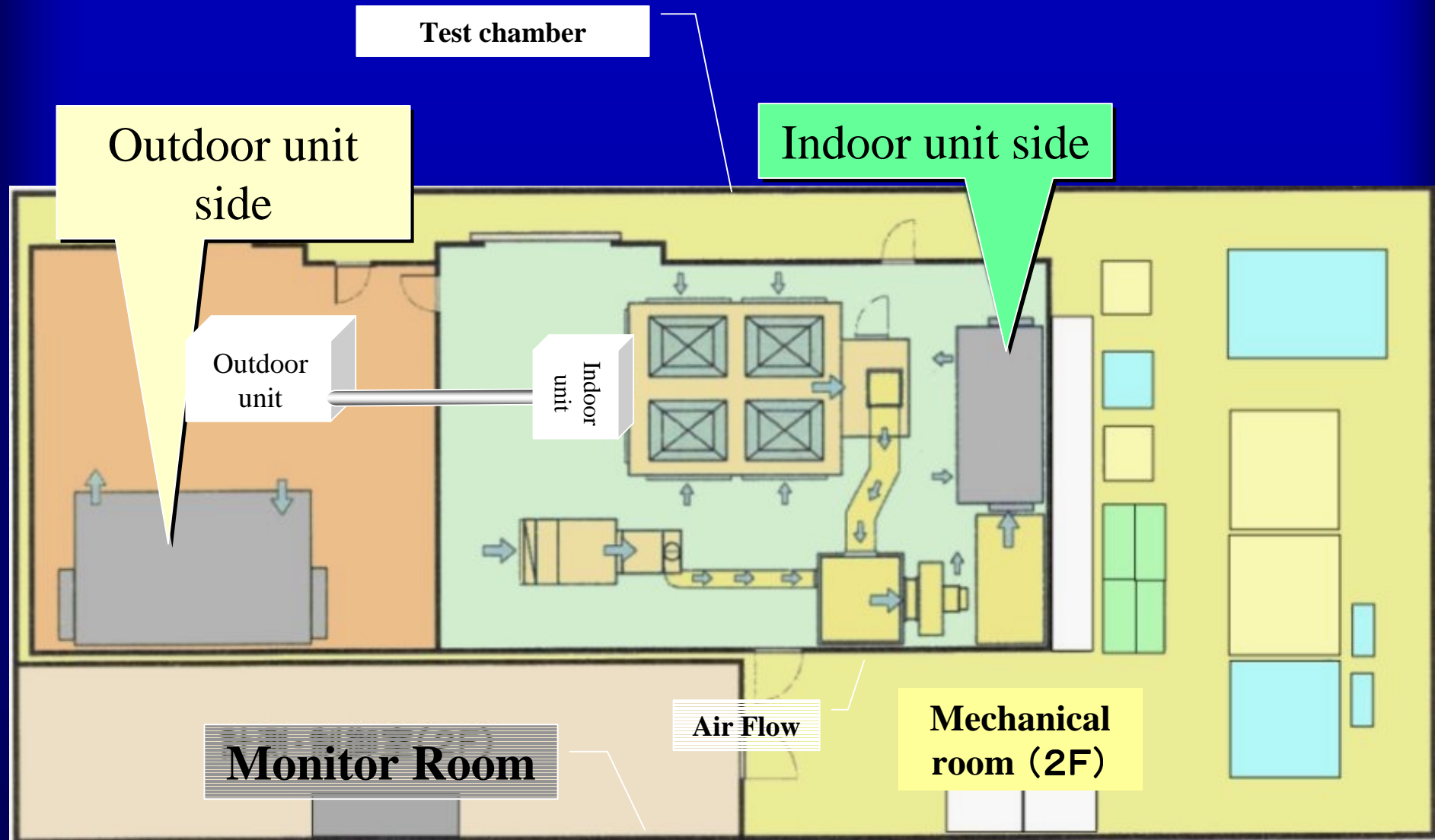
$C_D=0.25$ at 100% of seasonal power consumption



Calculated

When $C_D < 0.25$, the decrease of intermittent running efficiency is limited (Save energy)

Schematic of Measurement



Items of measurement

Cooling

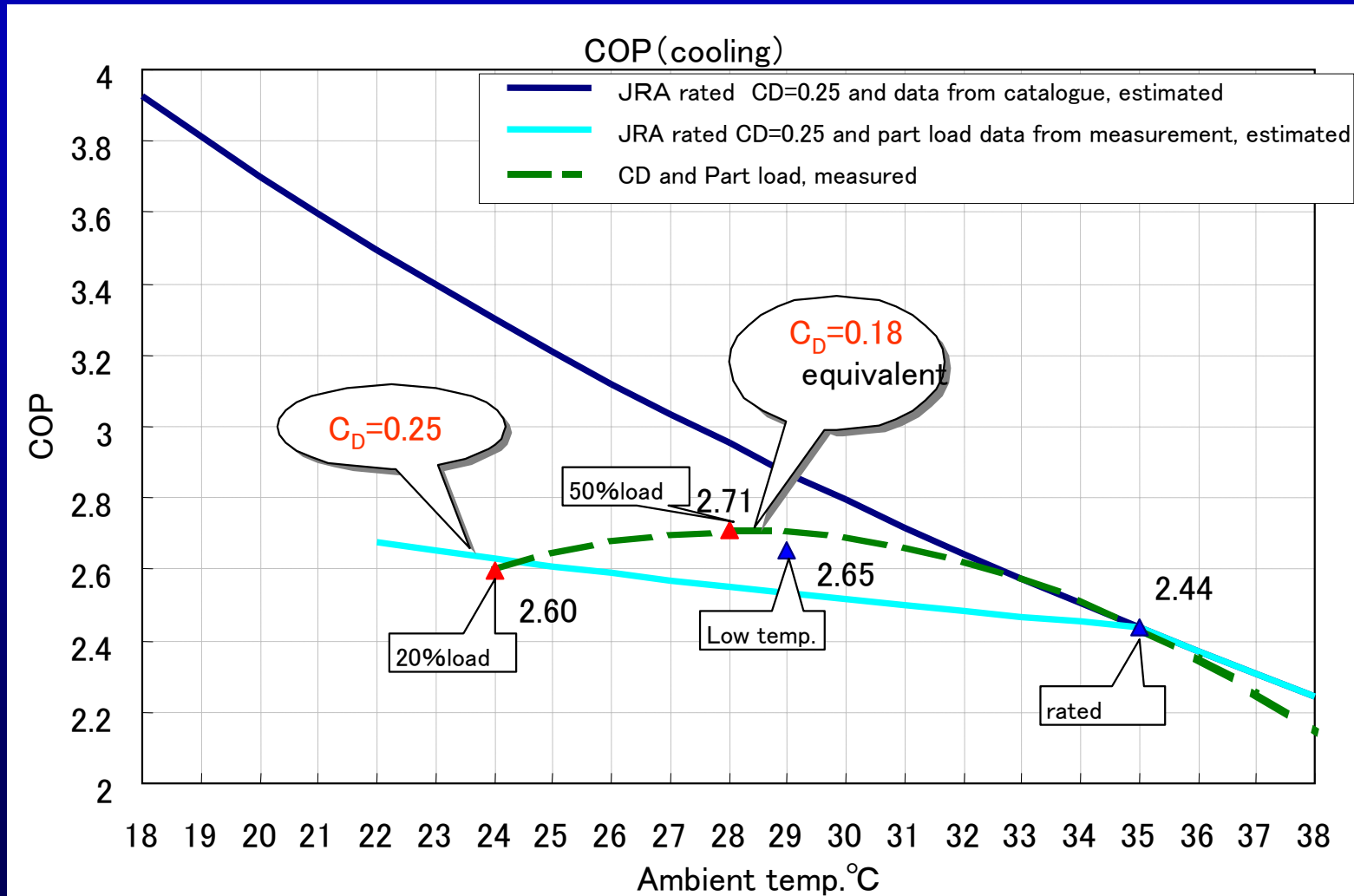
- ◆ Standard measurement (Rated)
- ◆ Minimum capacity measurement
- ◆ Part load measurement (30% ~ 90%)
【 Change . Ambient temp 】

Heating

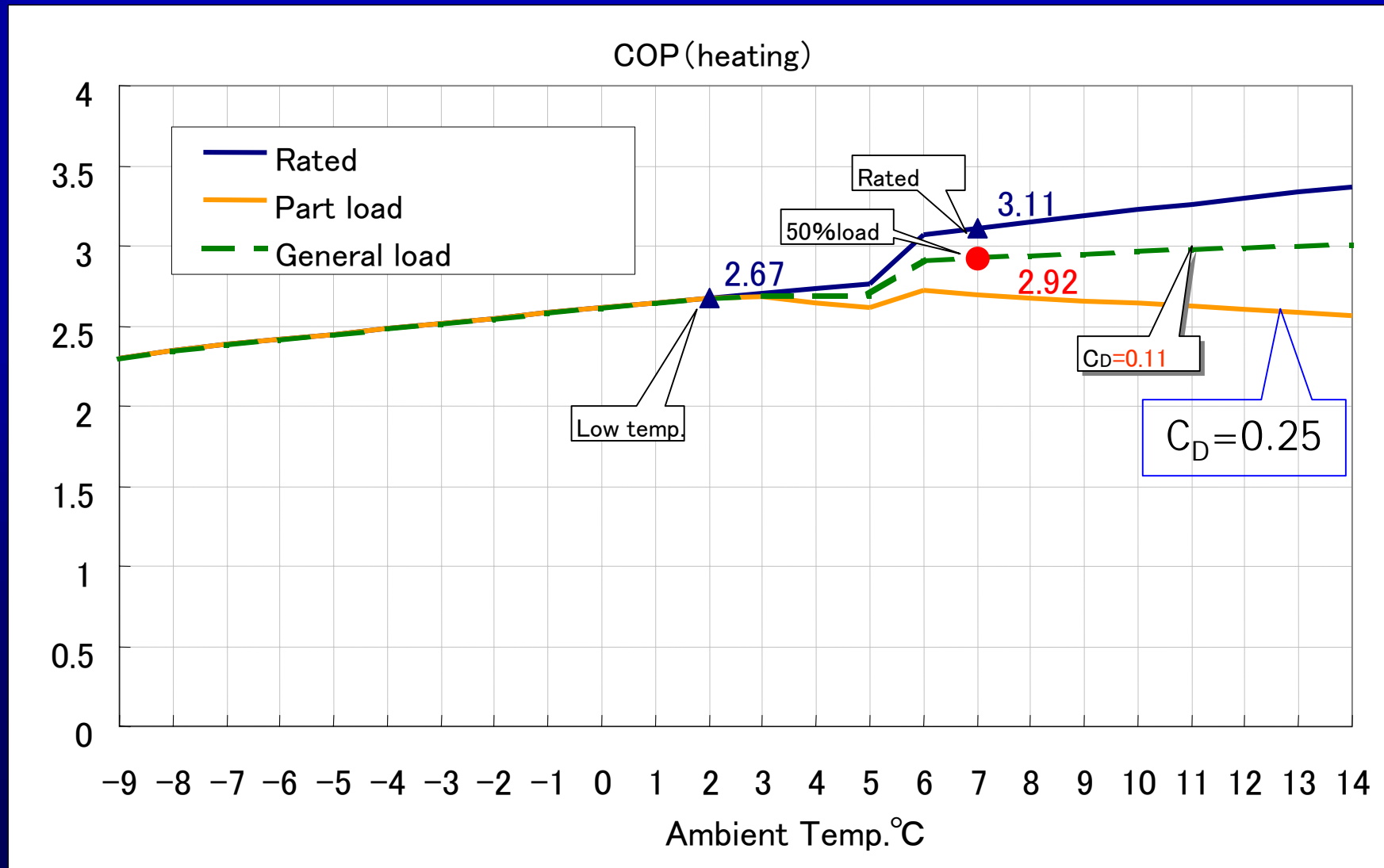
- ◆ Standard measurement (Rated)
- ◆ Minimum capacity measurement
- ◆ Part load measurement (30% ~ 90%)
【 Change . Ambient temp 】

A: Cooling at constant speed

Assumed load from a detached house

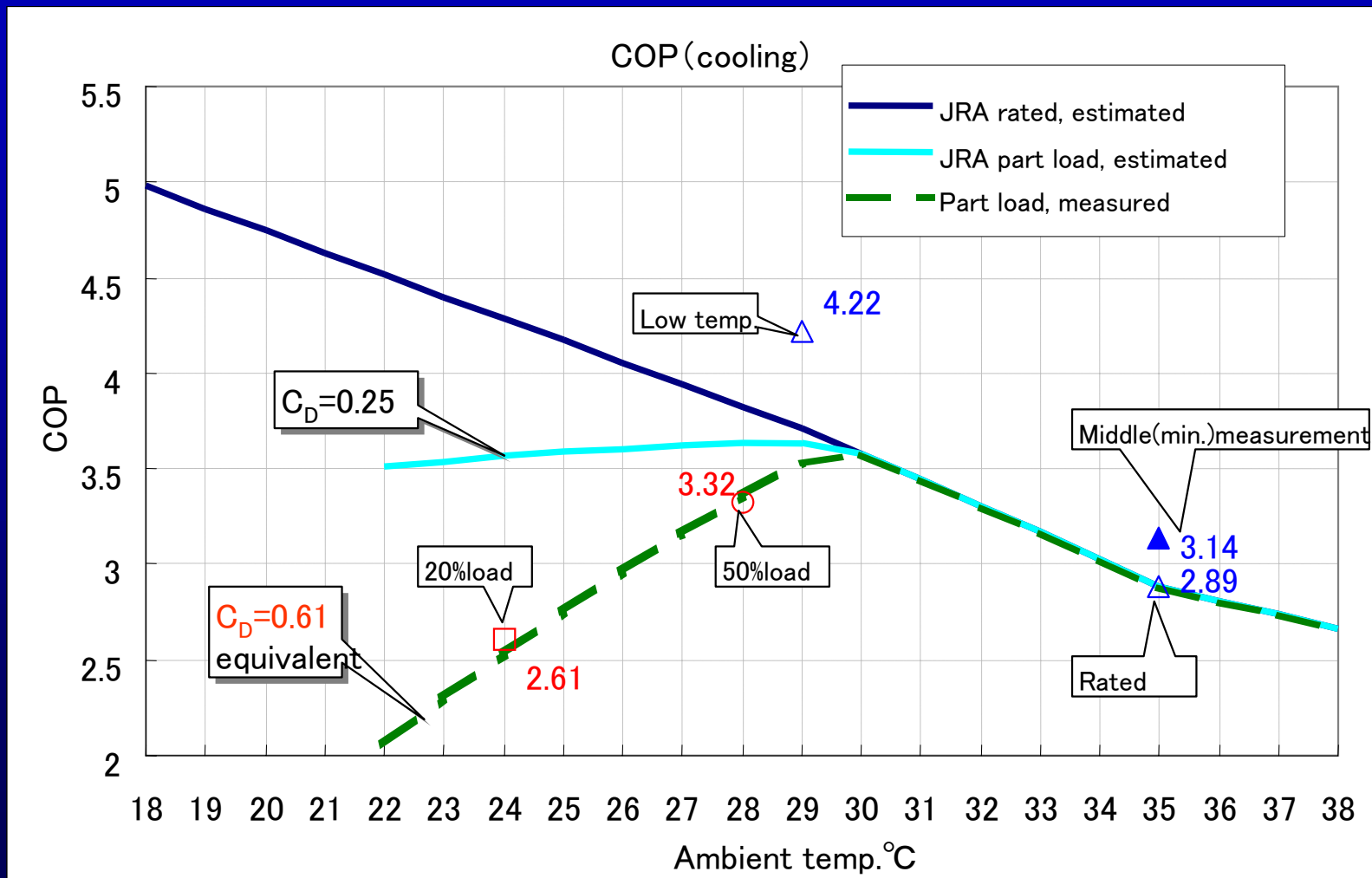


A: Heating at constant speed

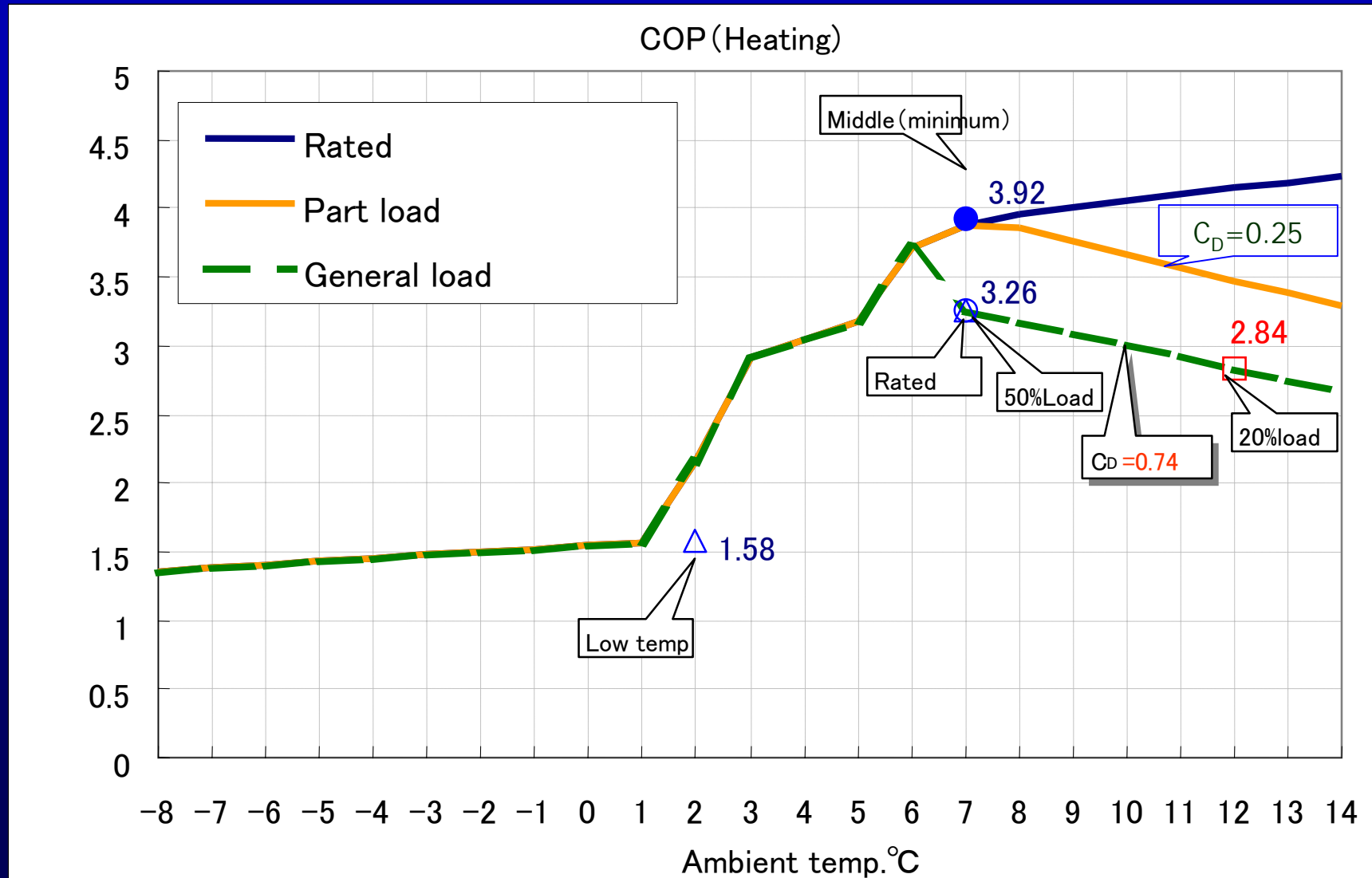


B: Cooling with inverter

Assumed load from a detached house(store)

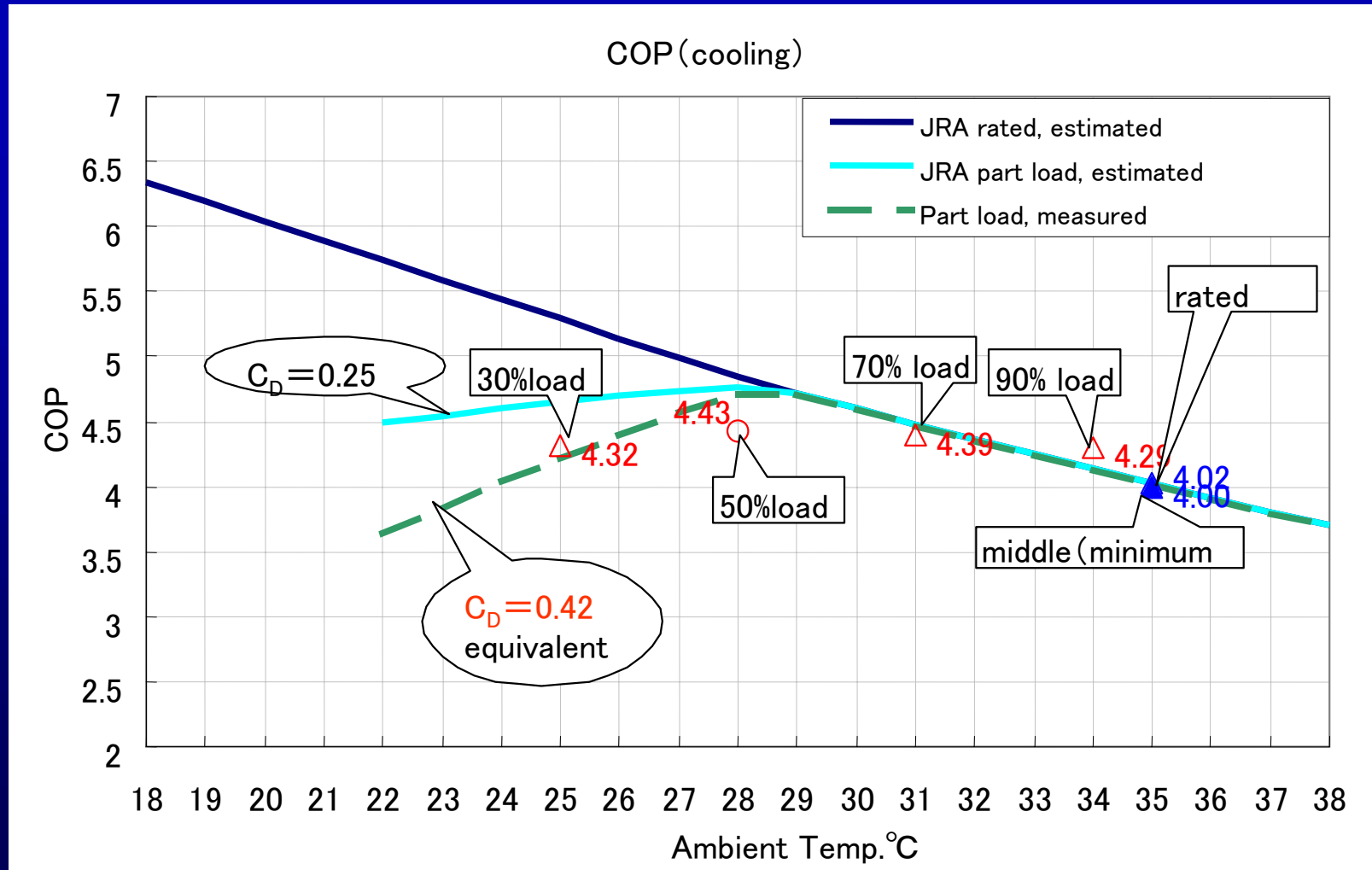


B: Heating with inverter

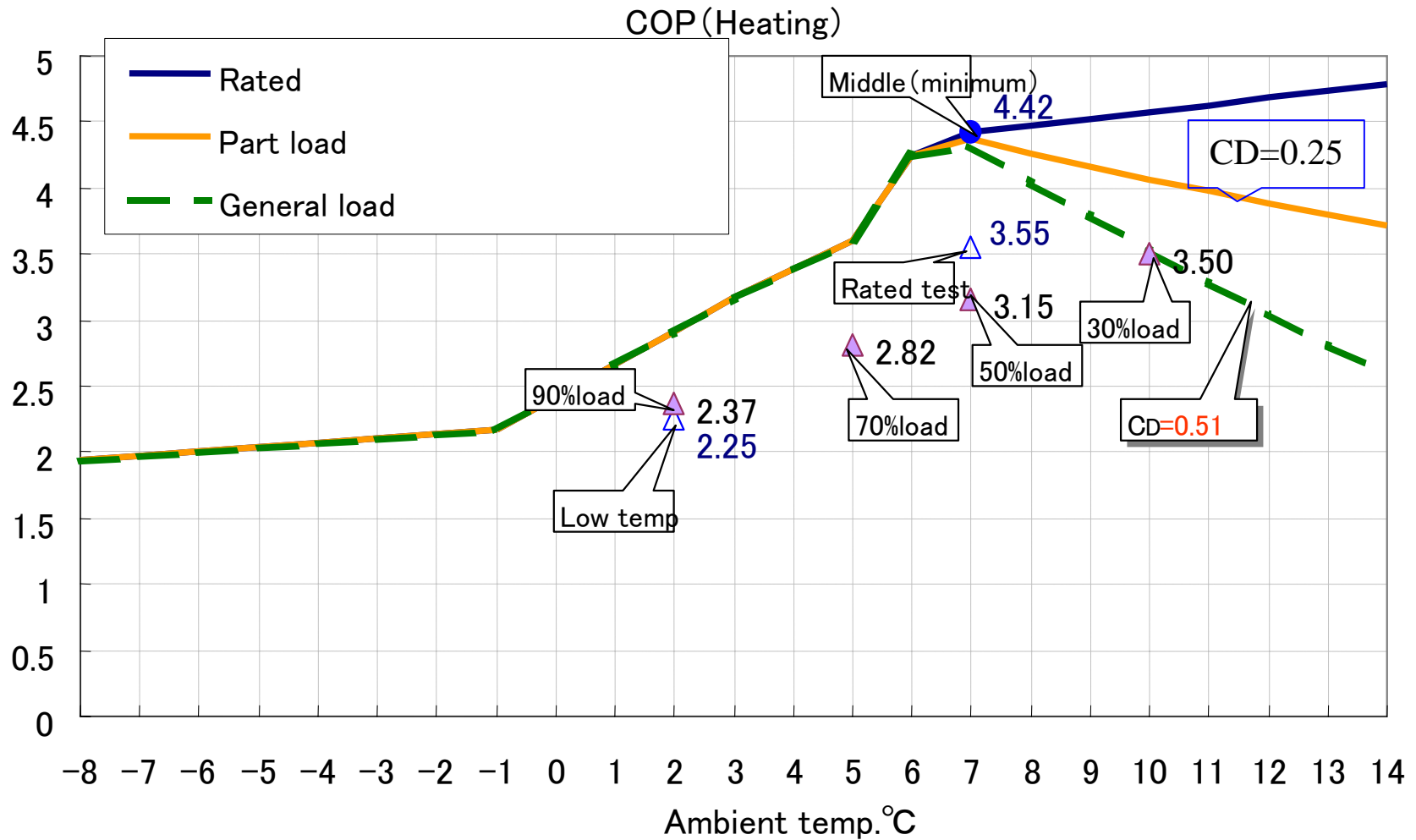


C: Cooling with inverter

Assumed load from a detached house (store)



C: Heating with inverter



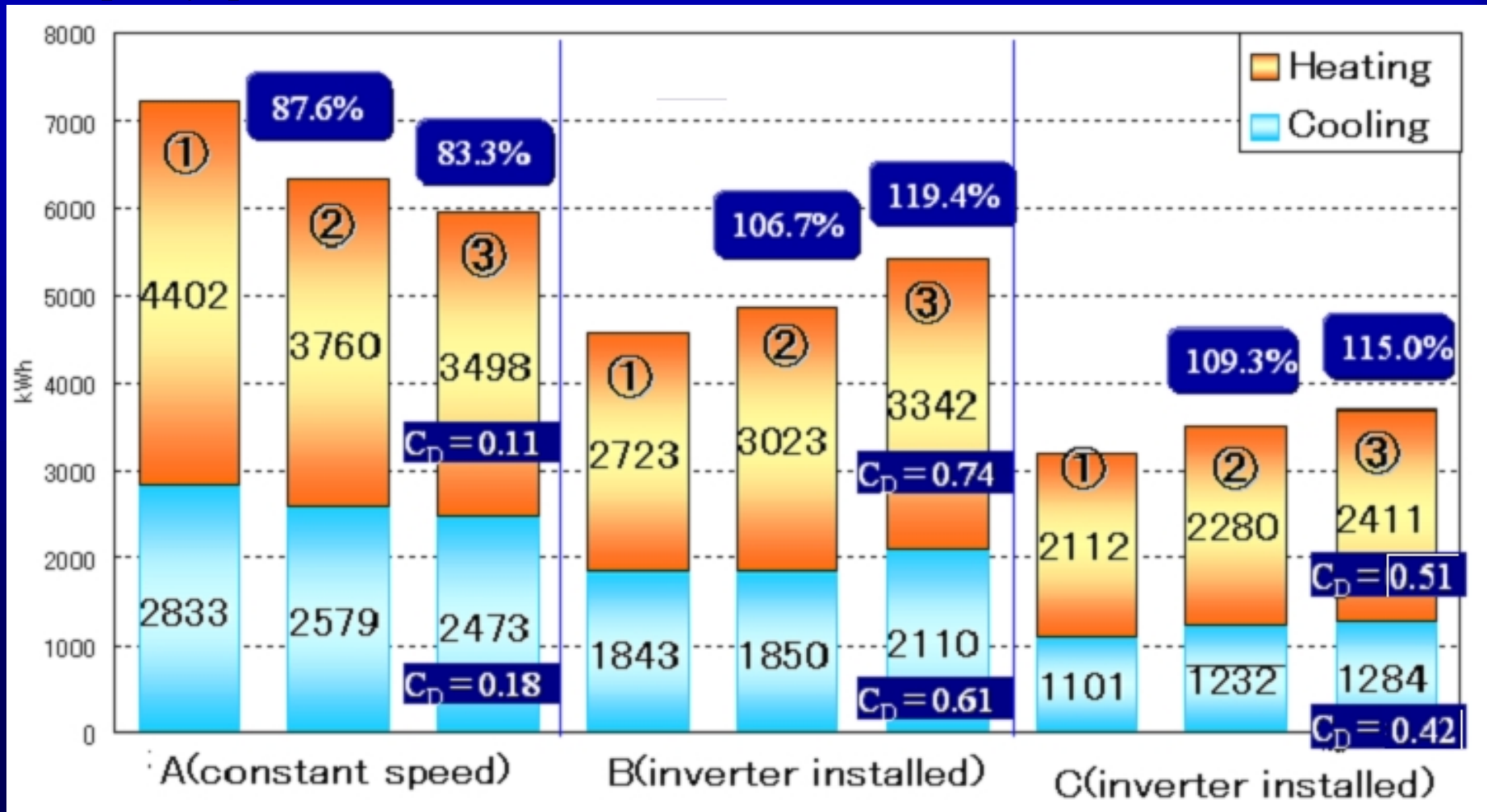
Estimated and measured power consumption

① Capacity · power from specification ($C_D = 0.25$)

② Capacity · power from measurement ($C_D = 0.25$)

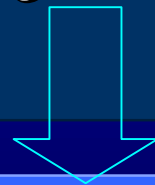
③ Capacity · power from measurement (C_D from measurement)

$C_D = 0.25$???



Conclusion

- The seasonal power consumption calculated using rated $C_D (=0.25)$ is obviously different from that obtained using measured C_D .
- It is difficult to predict intermittent performance using continuous performance.
- The assessment of energy consumption in middle loaded (intermittent) region using JRA standard is NOT reliable.
- Energy loss is very large for high rotation speed startup of inverter-installed units.



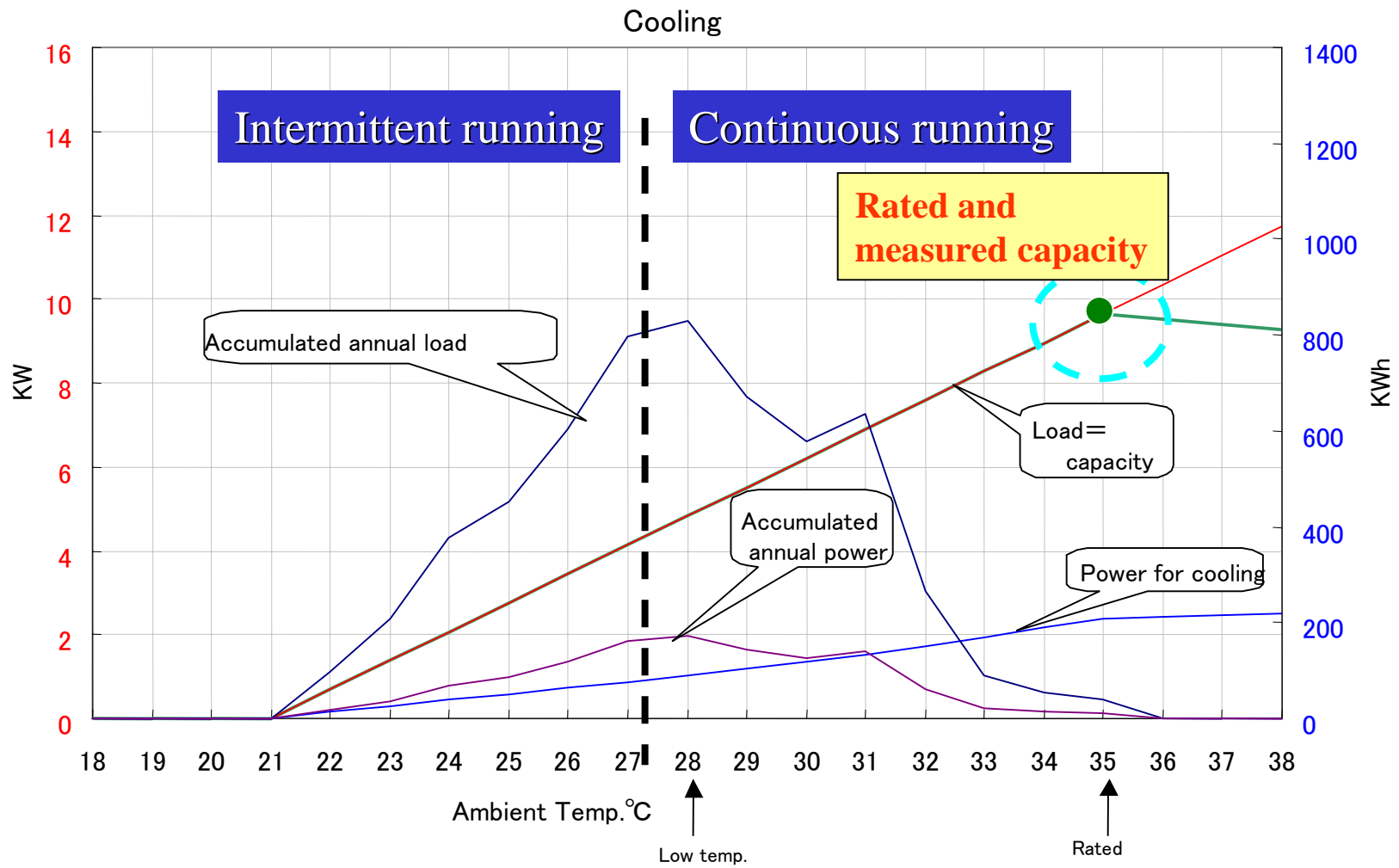
?-1: More appropriate method of assessing packaged air-conditioning units is necessary...

?-2: Reference to the annual performance estimation of carbon dioxide heat pumps...

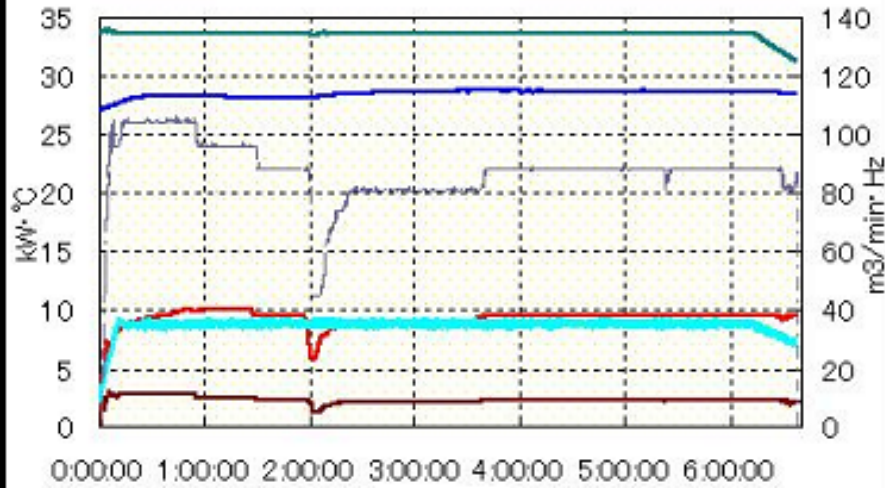
JRA Standards

- JIS C 9612:1999
- JIS B 8615:1999
- JIS B 8616
- JRA4048:2001

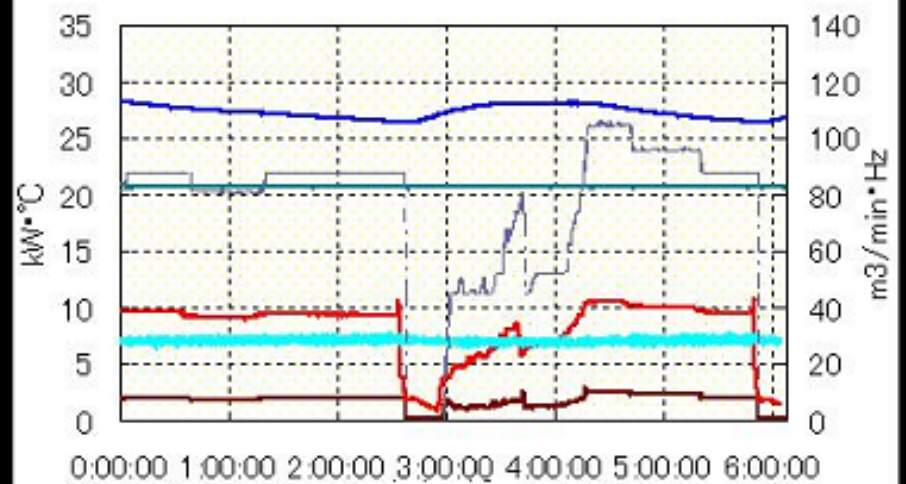
$$C_D = \frac{1 - COP_{c(cyc)} / COP_{c(dry)}}{1 - CLF} = \frac{1 - COP_{c(cyc)} / COP_{c(dry)}}{1 - Q_{c(cyc)} / Q_{c(dry)}}$$



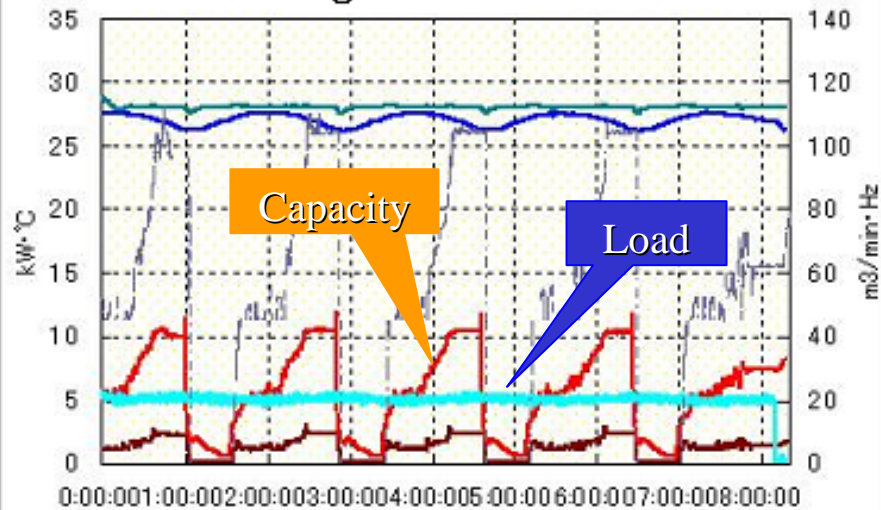
Cooling load 90%(33.6°C)



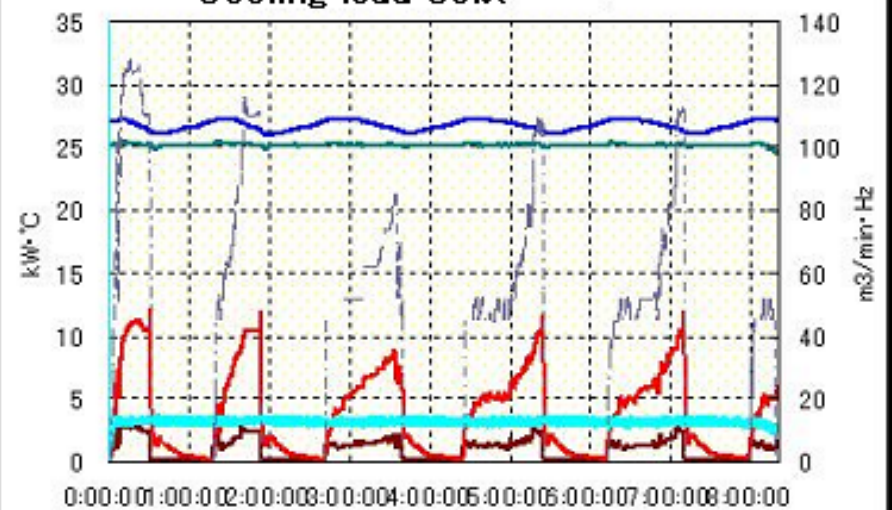
Cooling load 70%(30.8°C)



Cooling load 50%(28°C)



Cooling load 30%(25.2°C)



— Indoor temp.

— Outdoor temp.

— Indoor capacity

— Power

— Thermal Load

- - - Compressor freq.