

9. Thermal Considerations

| | page |
|--|------|
| 9.1 Overview | I-1 |
| 9.2 Efficiency and Dissipation power | I-1 |
| 9.3 Thermal resistance | I-2 |
| 9.4 Convection cooling | I-3 |
| 9.5 Forced air cooling | I-3 |
| 9.6 Notes on Thermal design | I-3 |
| 9.6.1 Baseplate temperature | I-3 |
| 9.6.2 Heat sink mounting | I-4 |
| 9.6.3 Installation of modules | I-5 |
| 9.7 Thermal design example | I-6 |
| 9.8 Efficiency vs. Output current | I-7 |
| 9.9 Heat sink size and Thermal resistance | I-12 |
| 9.10 Thermal curves | I-14 |
| 9.10.1 Measuring environment | I-14 |
| 9.10.2 Thermal curves | I-14 |

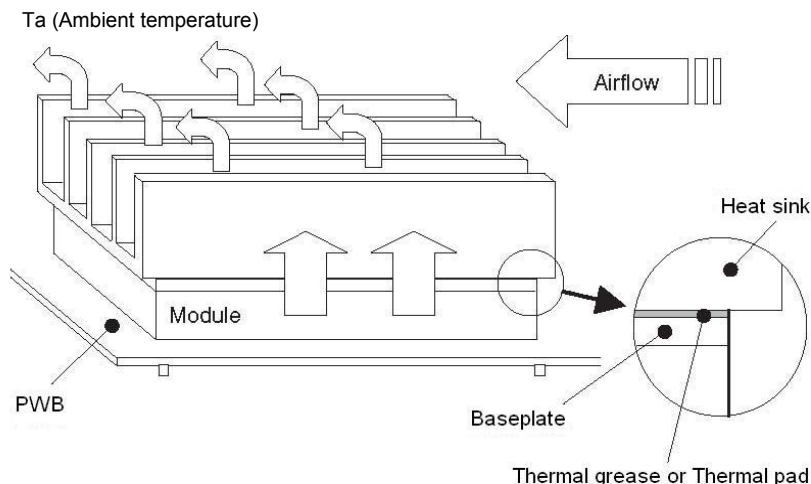
9.1 Overview

- To ensure operation of power module, it is necessary to keep baseplate temperature within the allowable temperature limit. The reliability of the power module depends on the temperature of the baseplate. In order to obtain maximum reliability, keep the aluminum base plate temperature low.
- Proper thermal design makes higher MTBF, smaller size and lower costs.

9.2 Efficiency and Dissipation power

- Not all of the input power is converted to output power, some loss is dissipated as heat power module inside. To determine the internal power dissipation, give 1 - 2 % margin of the efficiency value which is calculated by Characteristics of Efficiency vs. Output current.
- Efficiency is defined as percentage of Output power vs Input power. Efficiency (E) depends on input voltage and output current. Refer to the individual data. Here 'Efficiency characteristic of CBS2004812' is shown in Fig.8.2.2 as an example.

Table 9.2.1
Internal power
dissipated



$$P_{in} = V_{in} \times I_{in}$$

$$P_{out} = V_{out} \times I_{out}$$

$$\eta = \frac{P_{out}}{P_{in}} \times 100$$

$$P_d = \frac{1 - \eta}{\eta} \times P_{out}$$

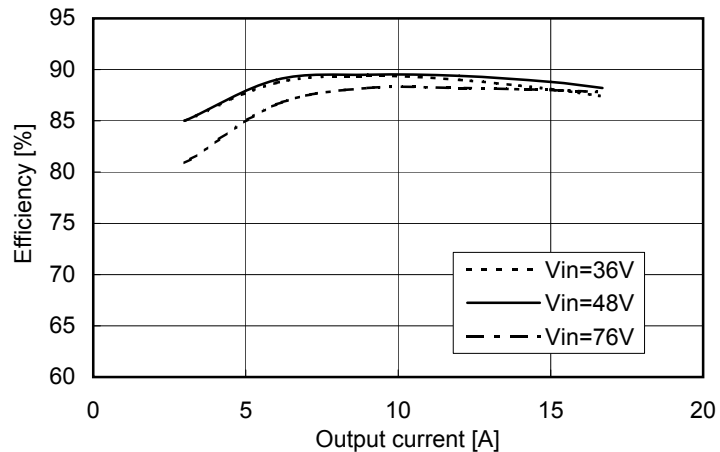
P_{in} : Input power (W)

P_{out} : Output power (W)

P_d : Internal power dissipated (W)

η : Efficiency (%)

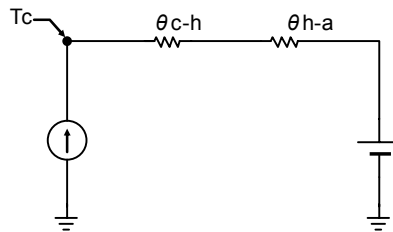
Fig.9.2.2
CBS2004812
Characteristics of
Efficiency vs.
Output current



9.3 Thermal resistance

- In most applications, heat will be conducted from the baseplate into an attached heat sink. Heat conducted across the interface between the baseplate and heat sink will result in a temperature drop which must be controlled. As shown in Fig.8.3.1, the interface can be modeled as a thermal resistance' with the dissipated power flow.

Fig.9.3.1
Thermal resistance



The thermal resistance of heat sink is calculated by following equation.

$$T_a \quad \theta_{h-a} = \frac{T_c - T_a}{P_d} - \theta_{c-h}$$

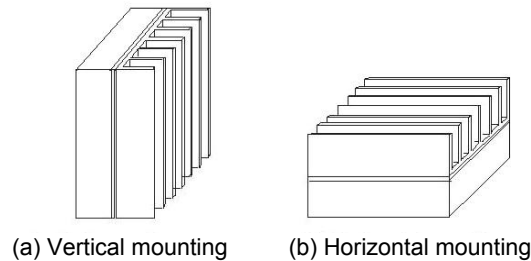
- θ_{h-a} : Thermal resistance of Heat sink ($^{\circ}\text{C}/\text{W}$) (Heat sink - Air)
- θ_{c-h} : Contact thermal resistance ($^{\circ}\text{C}/\text{W}$) (Baseplate - Heat sink)
- P_d : Internal power dissipated (W)
- T_c : Baseplate temperature ($^{\circ}\text{C}$)
- T_a : Ambient temperature ($^{\circ}\text{C}$)

- Contact thermal resistance is between baseplate and heat sink. To decrease the contact thermal resistance, use thermal grease and thermal pad. When using thermal grease, apply in a uniform thin coat.
- The thermal grease and thermal pad have the following respective features.
 - (1) Thermal grease : low thermal resistance ($0.2 - 0.3^{\circ}\text{C}/\text{W}$).
 - (2) Thermal pad. : higher than thermal grease ($0.3 - 0.4^{\circ}\text{C}/\text{W}$)

9.4 Convection cooling

- The benefits of convection cooling is low cost implementation, no need for fans, and the inherent reliability of the cooling process. Compared to forced air cooling, convection cooling needs more heat sink volume to cool down an equivalent baseplate temperature. Thermal resistance depends on heat sink shape. Therefore, refer to the detailed thermal resistance data supplied by the manufacturer prior to the selection.
- Heat sink data is almost always given for vertical fin orientation. Orienting the fins horizontally will reduce cooling effectiveness. If horizontal mounting is required, obtain relevant heat sink performance data or use forced air cooling.

Fig.9.4.1
Mounting method



9.5 Forced air cooling

- In forced air cooling method, heat dissipation ability of the heat sink improves much higher than convection cooling. Refer to 8.9 Heat sink size and Thermal resistance. Dirty environments will require filters that must be changed regularly to maintain cooling efficiency, and neglecting to change a filter or the failure of the fan could cause the system to shut down or malfunction.

9.6 Notes on Thermal design

9.6.1 Baseplate temperature

- DBS/CDS series : Refer to Fig.9.6.1 for derating curve.
- CBS series : Refer to Fig.9.6.2 for derating curve.
- Measure the baseplate temperature at the center of the baseplate.

Fig.9.6.1
The DBS/CDS series
derating curve

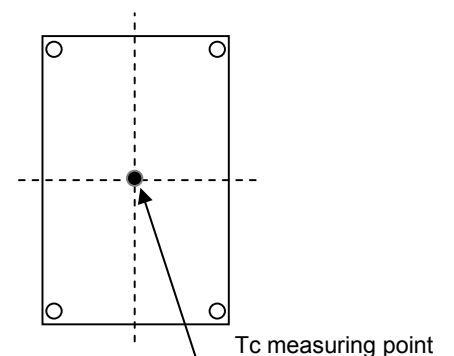
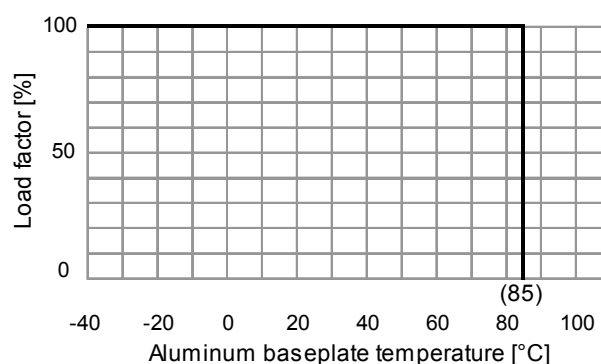
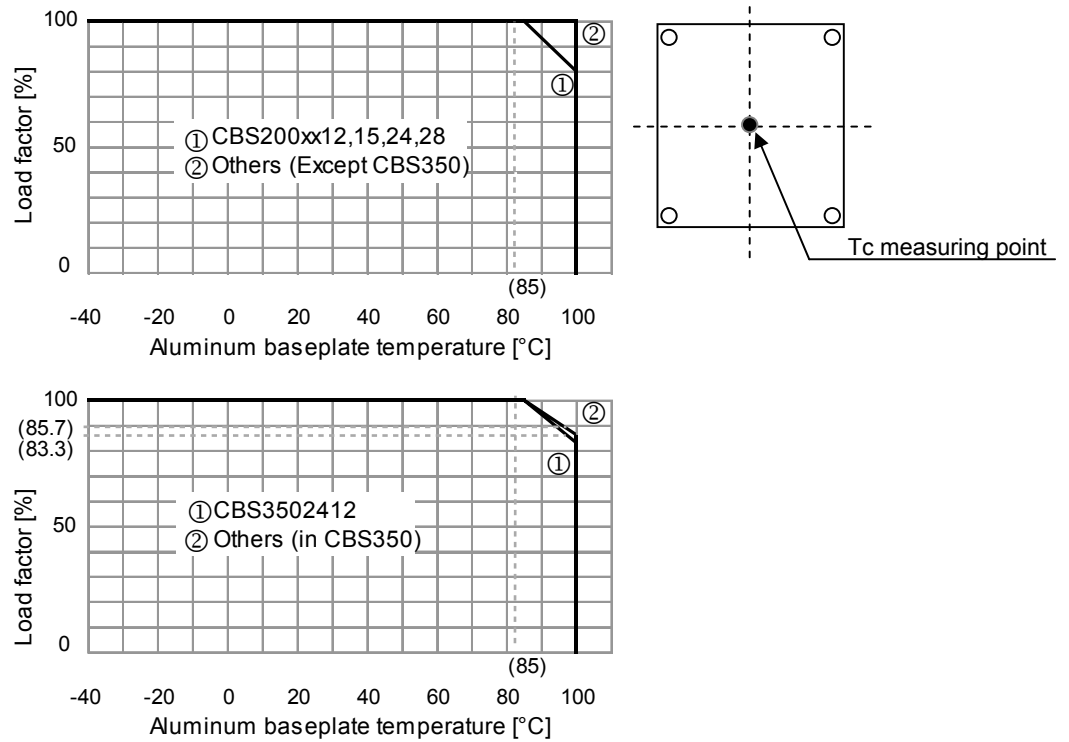
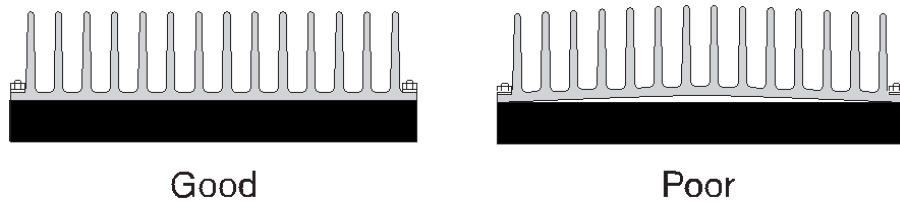


Fig.9.6.2
The CBS series
derating curve



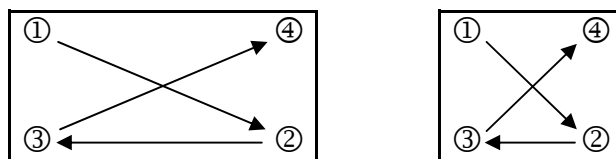
9.6.2 Heat sink mounting

- The interface between the baseplate and heat sink is smooth, flat and free of debris.
- Unless the baseplate and the heat sink are placed in close contact with each other, contact thermal resistance will increase until heat radiation becomes insufficient. Always use either thermal grease or thermal pads.



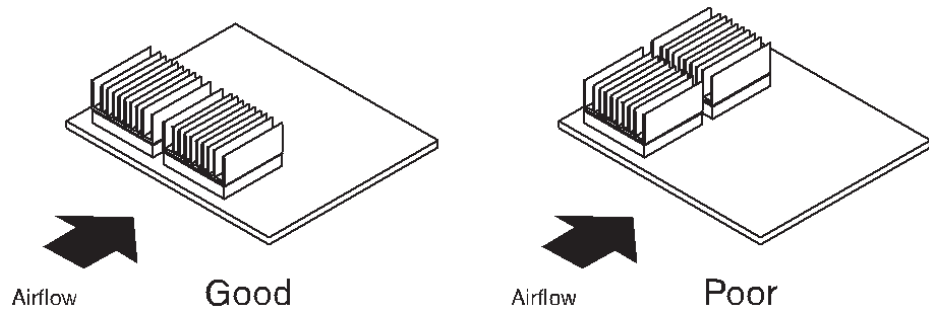
- To install the heat sink, fasten with screws through all four mounting holes.
- When mounting heat sinks to modules, use M3 screws torqued uniformly holes provided. The following tightening sequence should be used.
 - (1) Lightly finger-tighten all screws.
 - (2) Torque screws to 0.4N-m (5.0kg-cm) max as shown in Fig.8.6.3.

Table 9.6.3
Torquing sequence

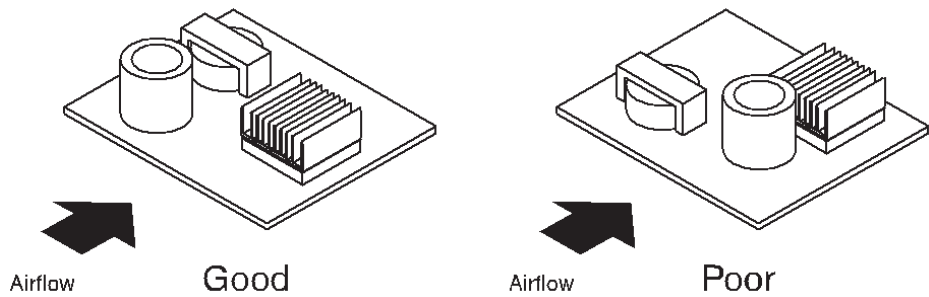


9.6.3 Installation of modules

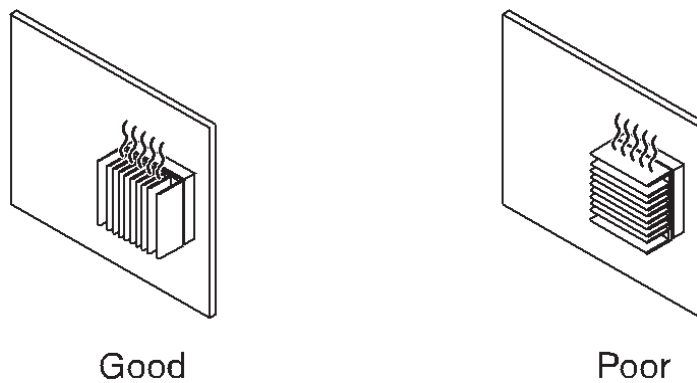
- Stagger modules to improve cooling and facilitate even heat distribution between modules.



- Avoid blocking the airflow to the modules with other components.



- Use a heat sink with fins running vertically for natural convection.



9.7 Thermal design example

- The process of thermal design is described through an example of CBS504805.

Conditions

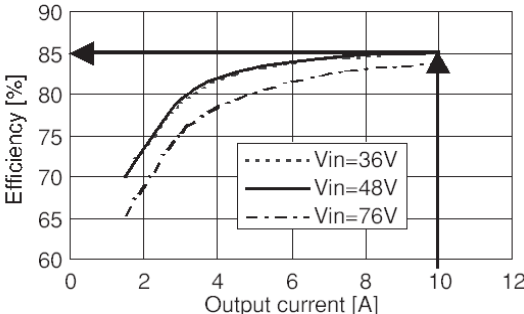
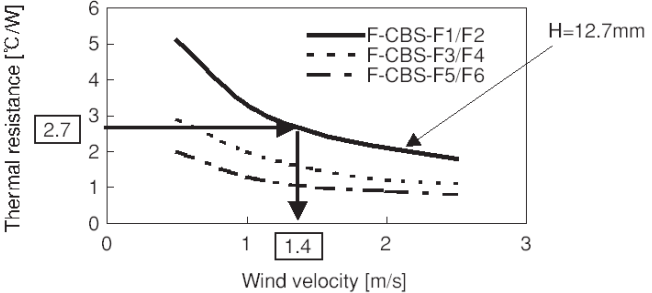
Input voltage = 48 [V]

Max. ambient temperature (Ta) = 50 [°C]

Aluminum baseplate temperature (Tc) = 80 [°C]

Output voltage = 5 [V]

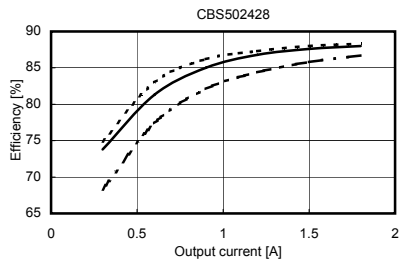
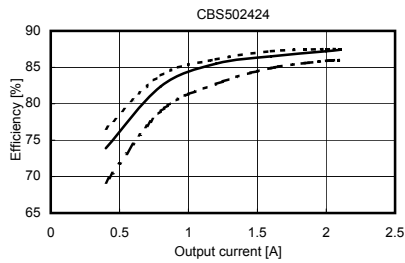
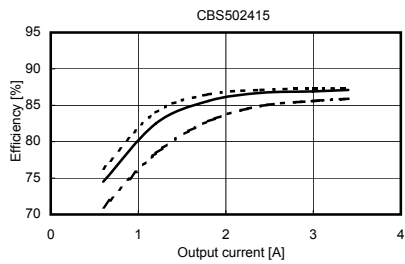
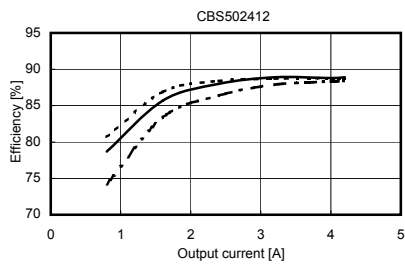
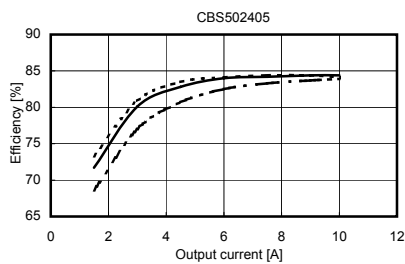
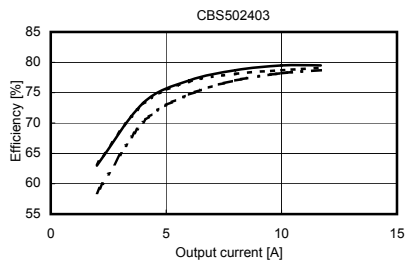
Output current = 10 [A]

| Step | Description | Design example |
|------|--|--|
| 1 | Determine the required output power (Pout) and ambient temperature (Ta) and aluminum baseplate temperature (Tc). | For higher reliability, the aluminum baseplate temperature is set up below 80C. Ta = 50 [°C] Pout = 5 [V] X 10 [A] = 50 [W] Tc = 80 [°C] |
| 2 | Obtain the efficiency (μ). | Efficiency (μ) is obtained by Fig.8.7.1. Refer to 8.8 Efficiency vs. Output current. The efficiency of CBS504805 is obtained by operating at rated input (DC48V). The efficiency is 85% at DC48V input voltage and 100% output current. To give 2% efficiency will be : Efficiency (μ) = 83 [%]  |
| 3 | Calculate the internal power dissipation (Pd). | $Pd = \frac{1 - 0.83}{0.83} \times 50 = 10.2 [W]$ |
| 4 | Obtain contact thermal resistance (θc-h). | Use a thermal grease with a thermal resistance of 0.2°C/W. |
| 5 | Calculate thermal resistance of Heat sink (θh-a). | $Th-a = \frac{80 - 50}{10.2} - 0.2 = 2.7 [°C/W]$ |
| 6 | Choose the heat sink. | Use a heat sink with H = 12.7mm. Refer to Fig.8.9.1 F-CBS-F1. |
| 7 | Obtain the required wind velocity. | Wind velocity is obtained by Fig.8.7.2. The wind velocity required to reduce the resistance to set up 2.7°C/W or below. Refer to 8.9 Heat sink size and Thermal resistance. Wind velocity required here is 1.4m/s or higher.  |
| 8 | Choose the fan. | Choose the fan capable of supplying air at a velocity of 1.4m/s or higher. |
| 9 | Check the design with actual equipment. | Experience shall be conducted with CBS504805. Measure the aluminum baseplate temperature at actual conditions (Pout = 50W, Ta= 50°C). Then confirm the baseplate temperature has been kept below 80°C. The thermal design is completed. |

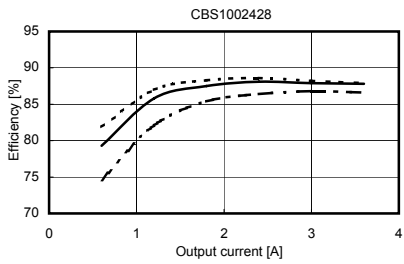
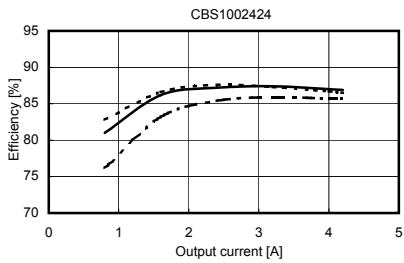
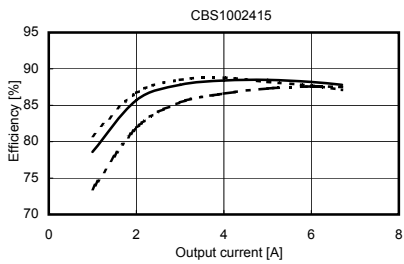
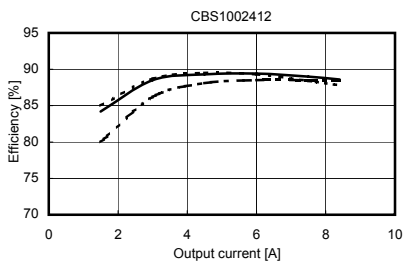
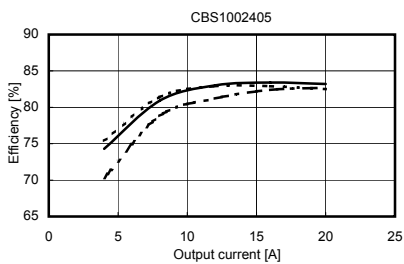
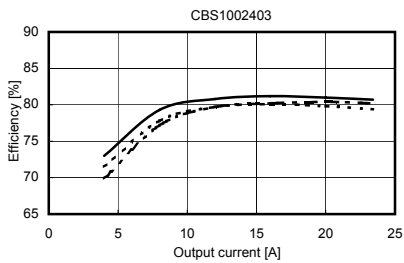
9.8 Efficiency vs. Output current

■ CBS series

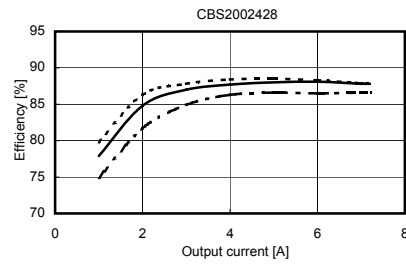
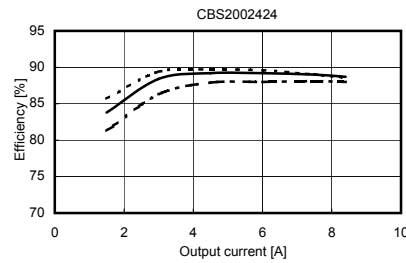
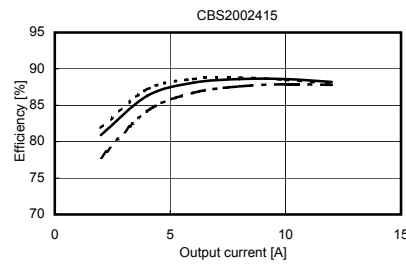
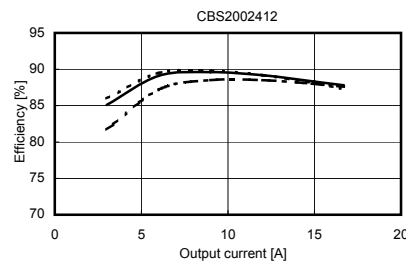
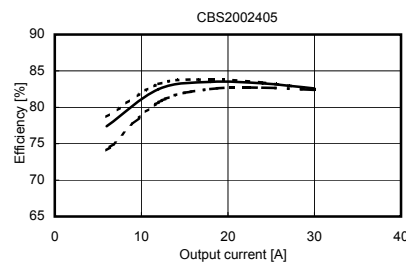
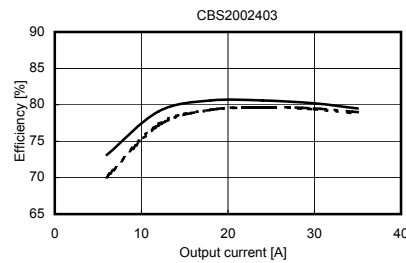
CBS5024xx



CBS10024xx

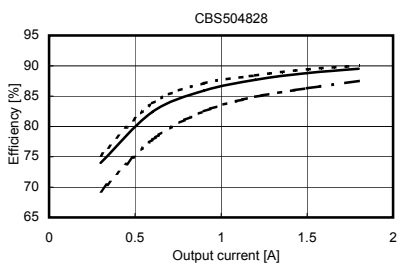
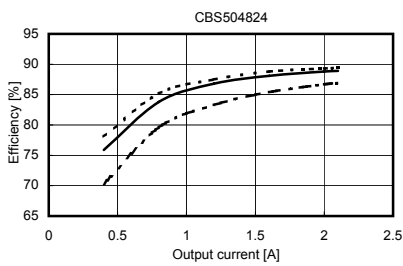
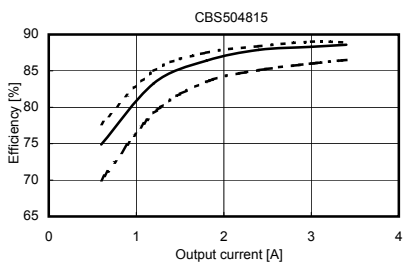
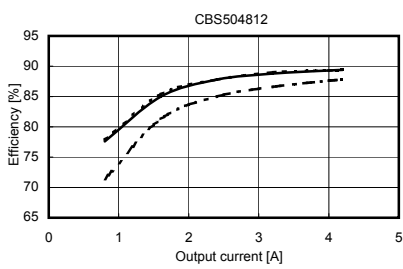
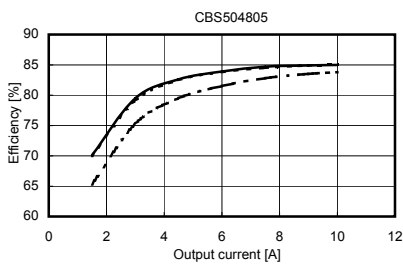
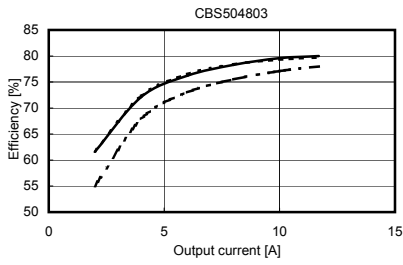


CBS20024xx

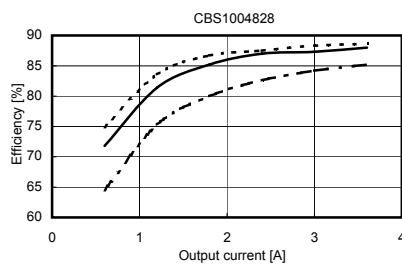
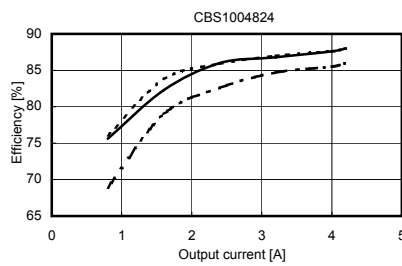
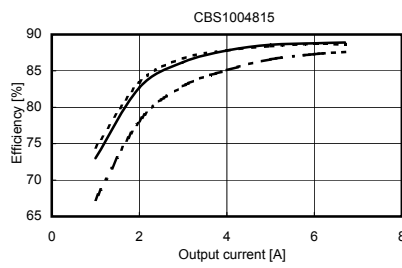
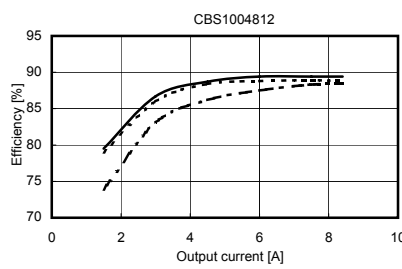
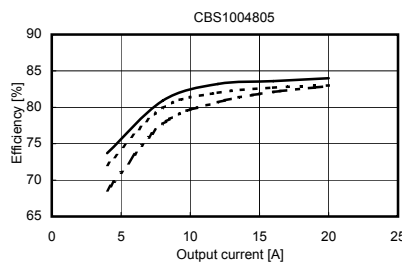
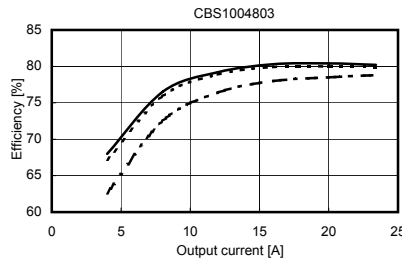


Thermal Considerations

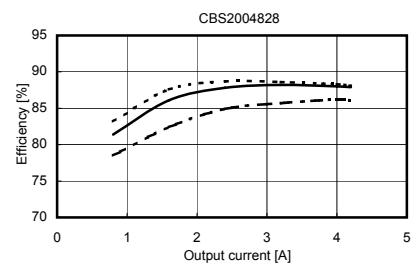
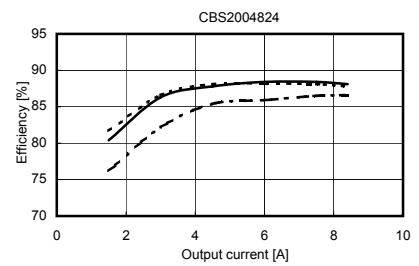
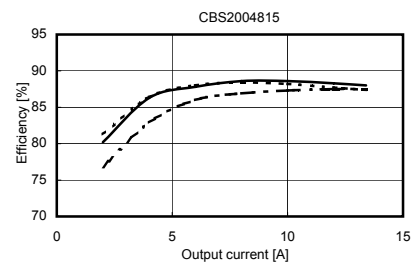
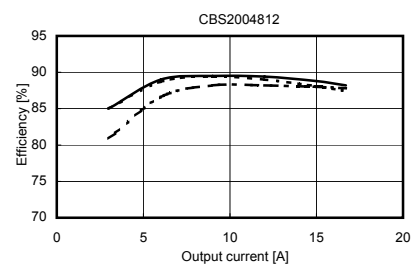
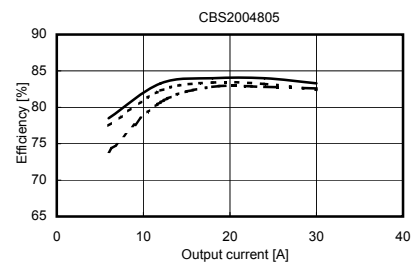
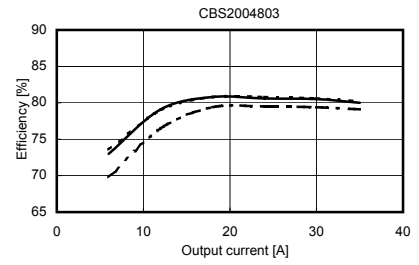
CBS5048xx



CBS10048xx

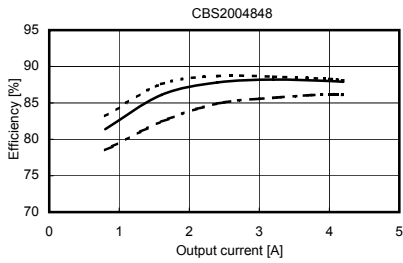


CBS20048xx

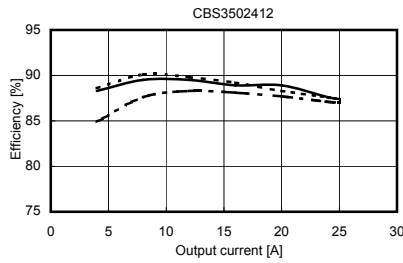


Thermal Considerations

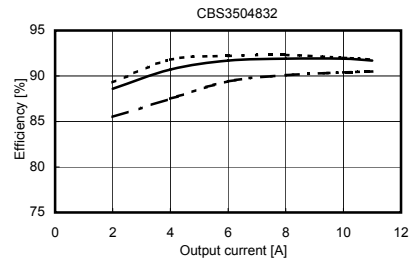
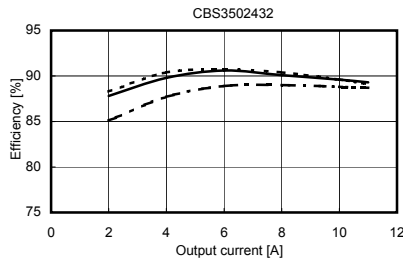
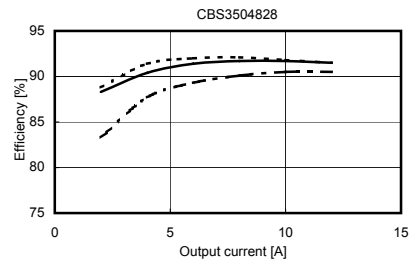
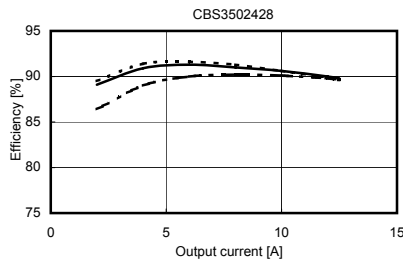
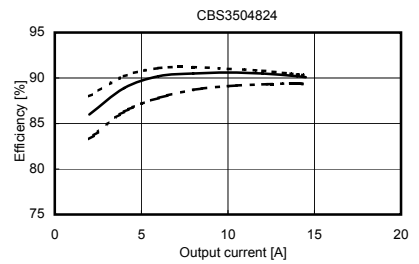
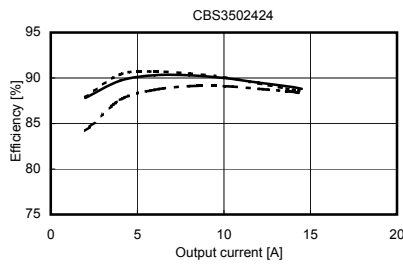
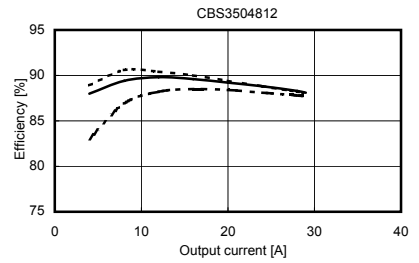
CBS20048xx



CBS35024xx



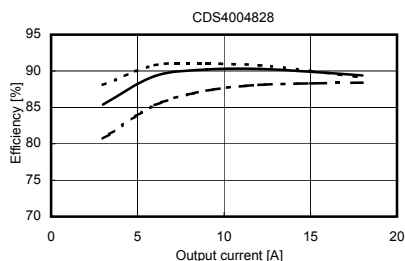
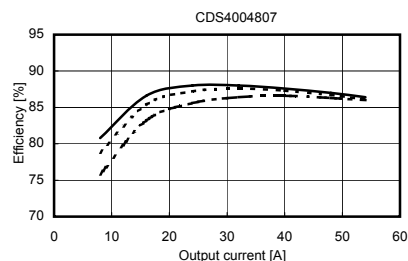
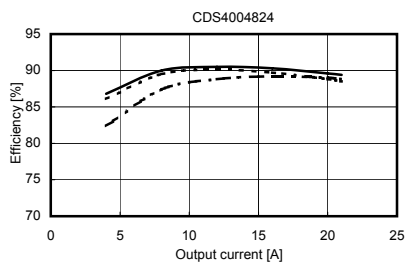
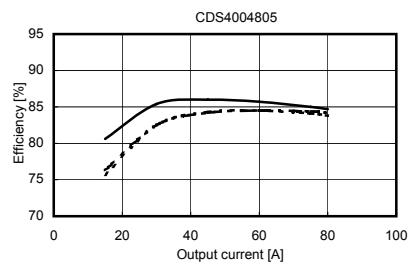
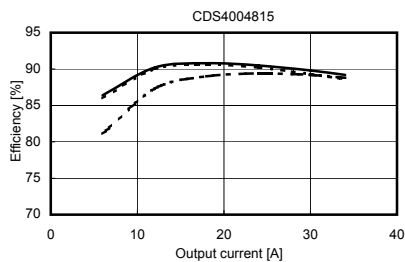
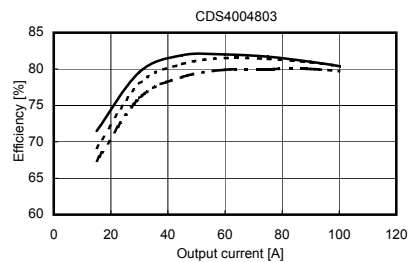
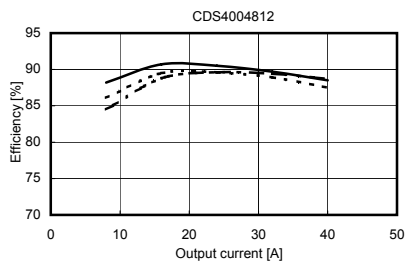
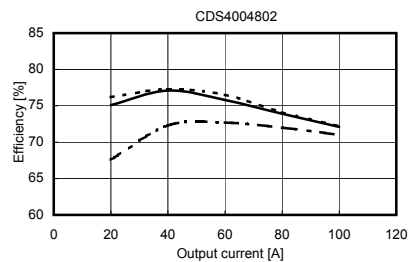
CBS35048xx



Thermal Considerations

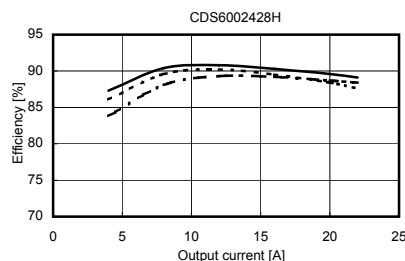
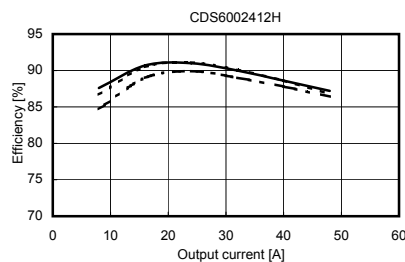
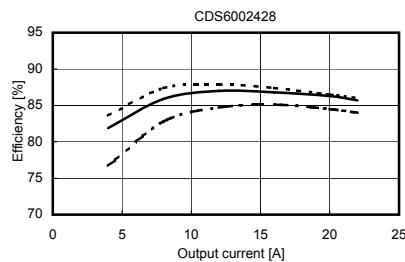
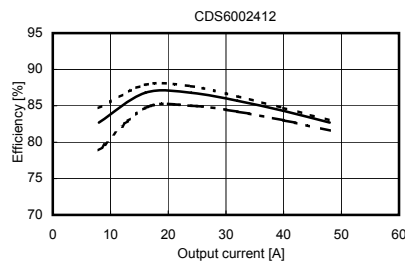
■ CDS series

CDS40048xx



CDS60024xx

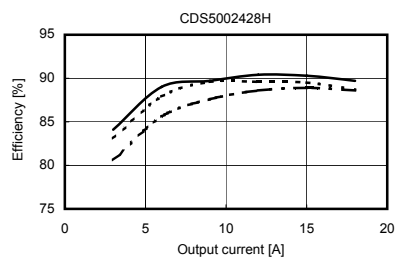
*1)



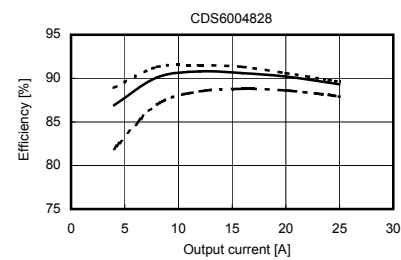
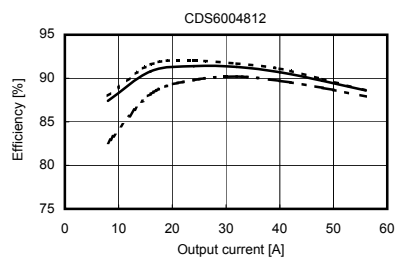
*1) CDS6002412H: Vin=20.5V

CDS6002428H: Vin=19V

CDS500



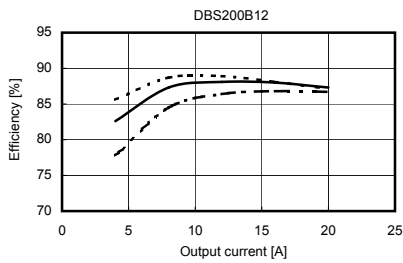
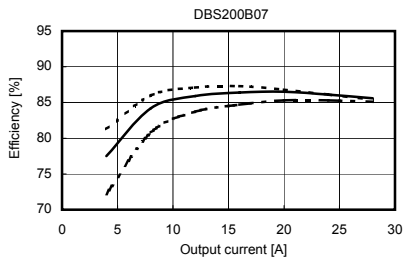
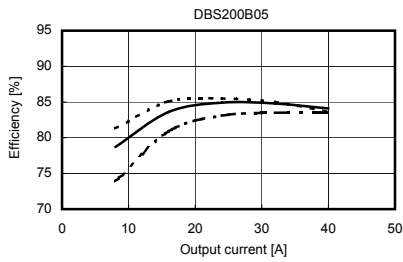
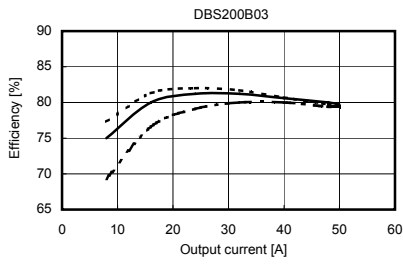
CDS60048xx



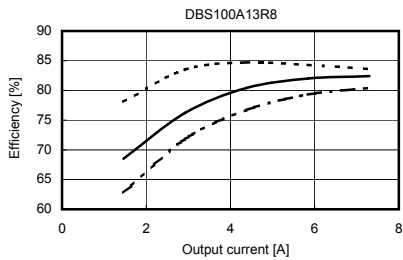
Thermal Considerations

■ DBS series

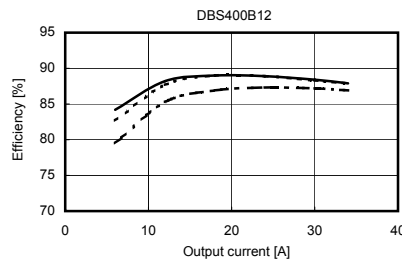
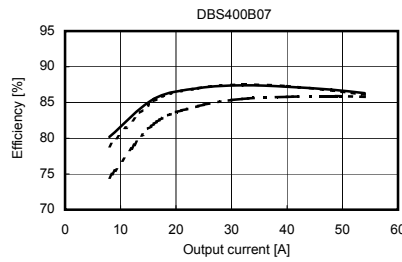
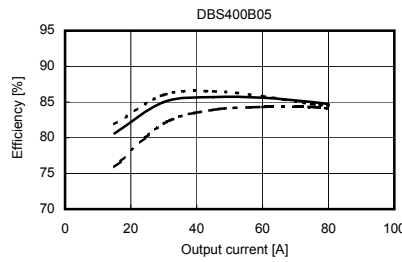
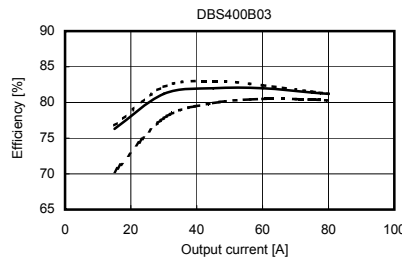
DBS200Bxx



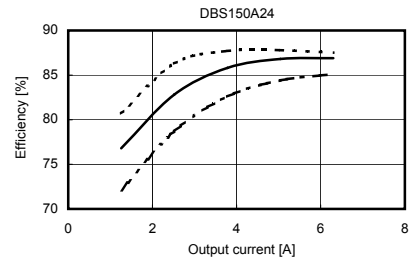
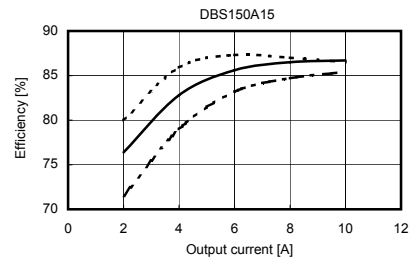
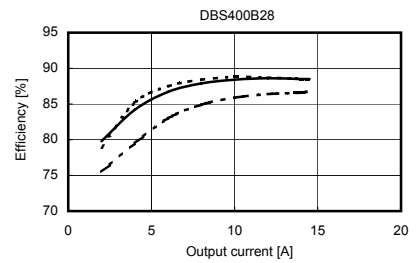
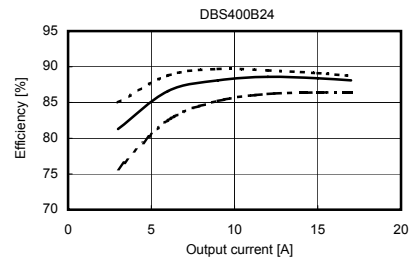
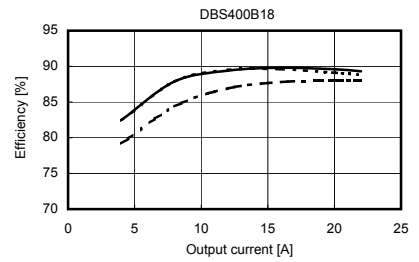
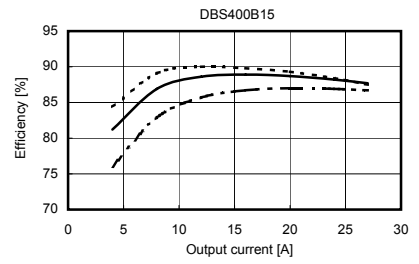
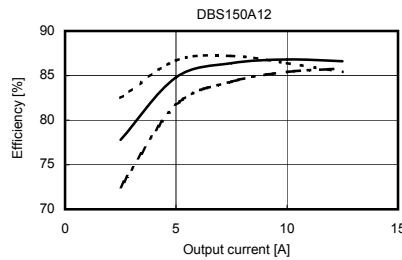
DBS100Axx



DBS400Bxx



DBS150Axx



9.9 Heat sink size and Thermal resistance

■ Half Brick size

Heat sink is prepared in CBS series Optional Parts.

Chart : List of Heat sink for CBS series

| No. | Model | Size [mm] | | | Thermal resistance [°C/W] | | Style |
|-----|----------|-----------|------|------|---------------------------|--------------------|------------|
| | | H | W | D | Convection (0.1m/s) | Forced Air | |
| 1 | F-CBS-F1 | 12.7 | 57.9 | 61.5 | 7.5 | Refer Fig.8.9.7 | Vertical |
| 2 | F-CBS-F2 | 12.7 | 58.4 | 61.0 | | | Horizontal |
| 3 | F-CBS-F3 | 25.4 | 57.9 | 61.5 | 4.6 | | Vertical |
| 4 | F-CBS-F4 | 25.4 | 58.4 | 61.0 | | | Horizontal |
| 5 | F-CBS-F5 | 38.1 | 57.9 | 61.5 | 3.0 | | Vertical |
| 6 | F-CBS-F6 | 38.1 | 58.4 | 61.0 | | | Horizontal |

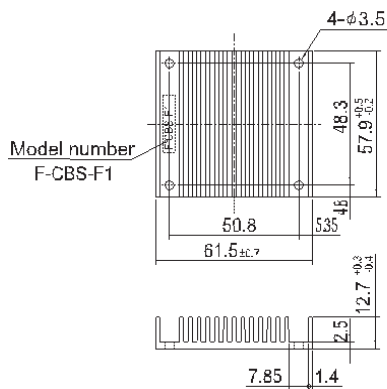


Fig.9.9.1 F-CBS-F1 (external view)

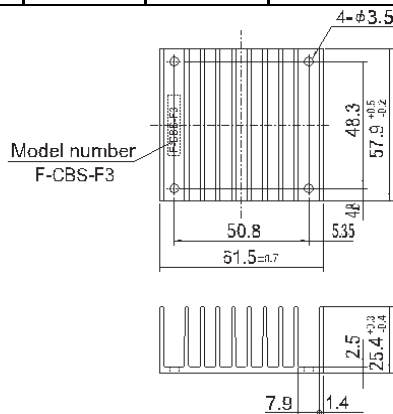


Fig.9.9.2 F-CBS-F3 (external view)

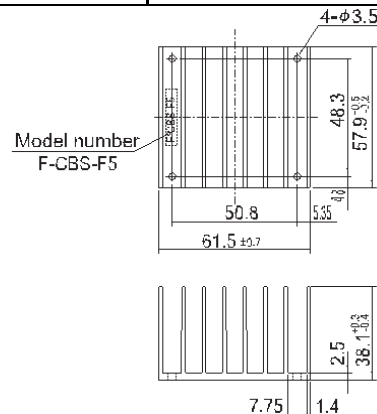


Fig.9.9.3 F-CBS-F5 (external view)

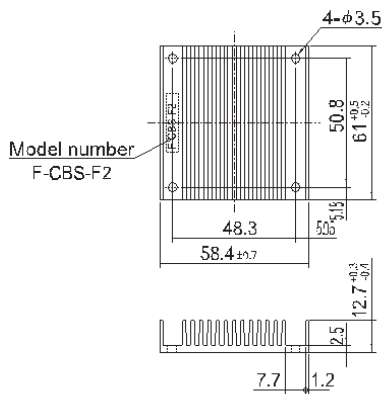


Fig.9.9.4 F-CBS-F2 (external view)

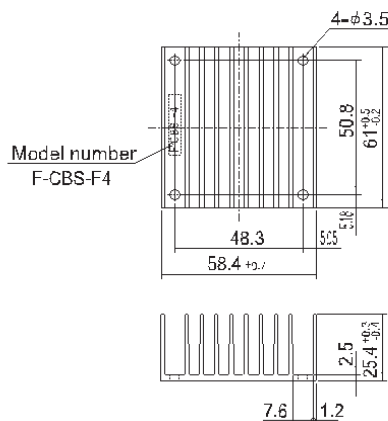


Fig.9.9.5 F-CBS-F4 (external view)

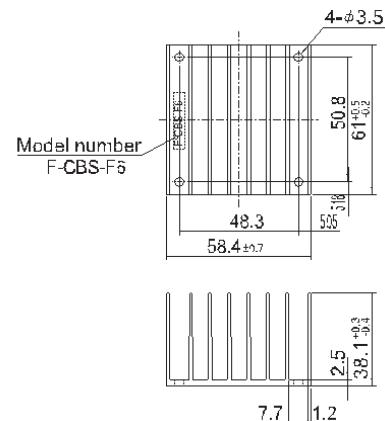
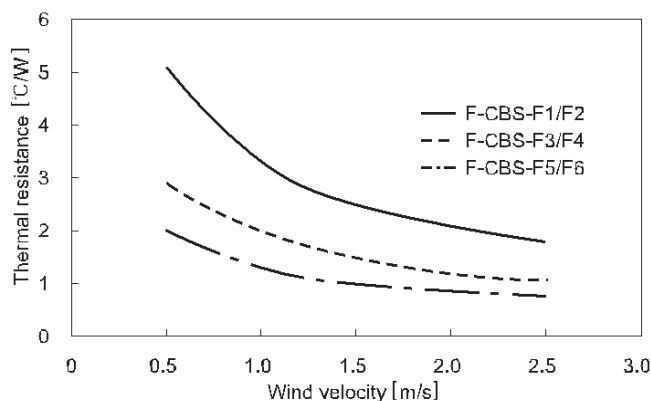


Fig.9.9.6 F-CBS-F6 (external view)

Fig.9.9.7
Heat sink thermal
resistance curves



Thermal Considerations

- Full Brick size

Chart : List of Heat sink for DBS/CDS series

| No. | Model | Size [mm] | | | Thermal resistance [°C/W] | | Style |
|-----|-------------|-----------|------|-------|---------------------------|---------------------|------------|
| | | H | W | D | Convection (0.1m/s) | Forced Air | |
| 1 | Heat sink A | 20.0 | 60.5 | 116.0 | 7.5 | Refer Fig.8.9.10 | Vertical |
| 2 | Heat sink B | 20.0 | 60.5 | 116.0 | | | Horizontal |

* Heat sink A and B are not sold in our company.

Fig.9.9.8
Heat sink A
(external view)

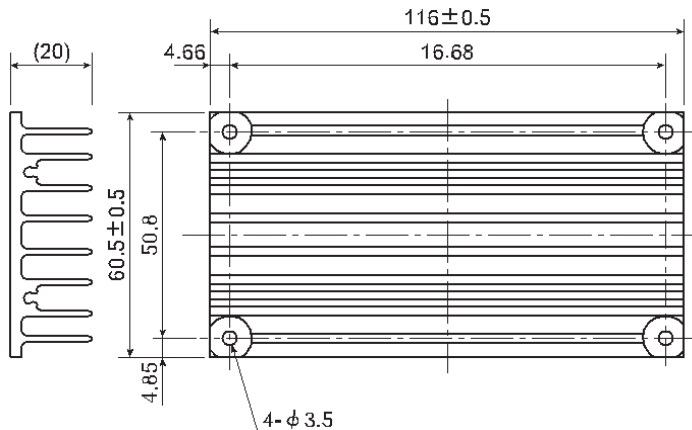


Fig.9.9.9
Heat sink B
external view

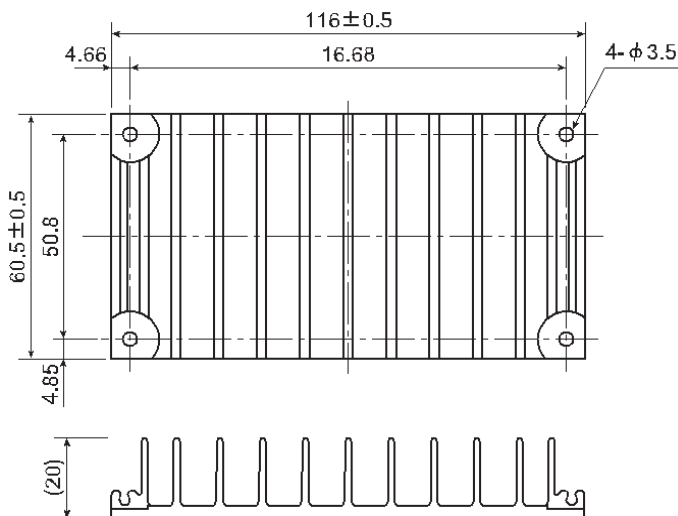
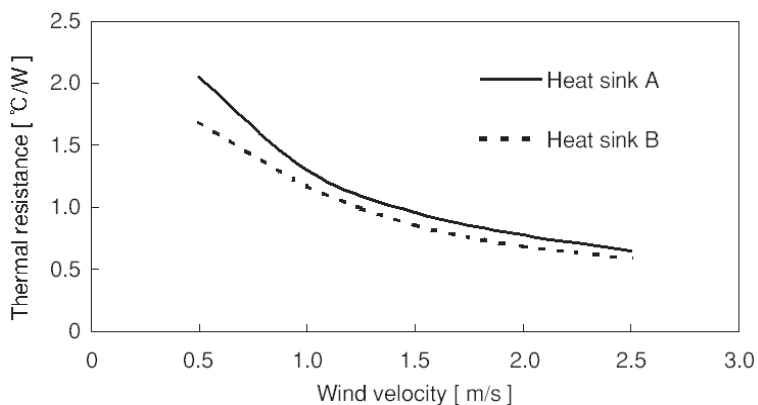


Fig.9.9.10
Heat sink thermal
resistance curves



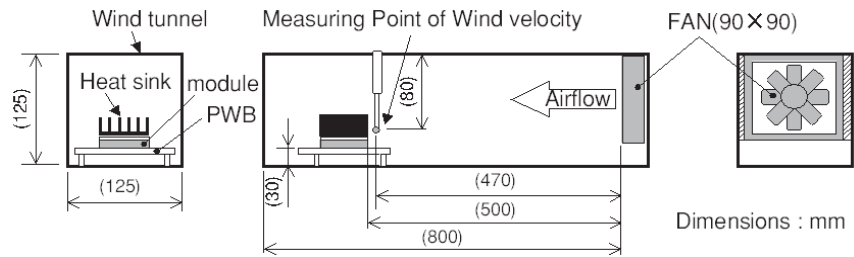
9.10 Thermal curves

Shown the Thermal curve with measuring environment as shown below.
 Verify final design by actual temperature measurement.

9.10.1 Measuring environment

- CBS series (Half Brick size)

Fig.9.10.1
 Measuring environment
 (CBS series)



- DBS/CDS series (Full Brick size)

Fig.9.10.2
 Measuring environment
 (DBS/CDS series)

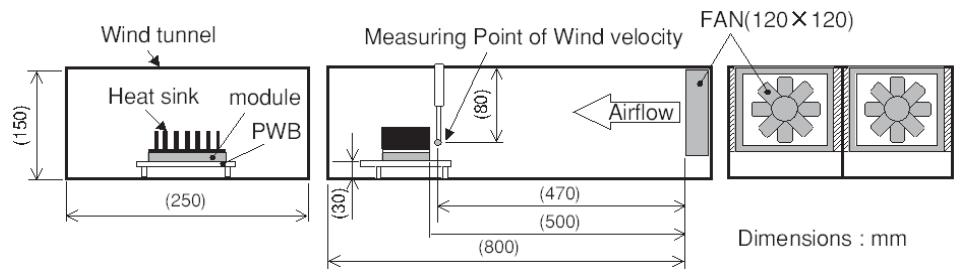
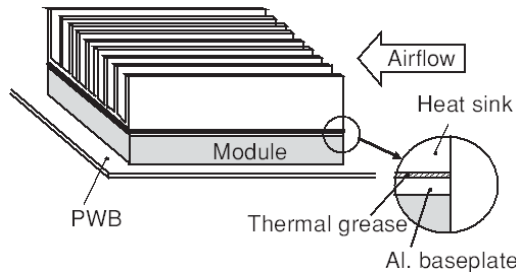


Fig.9.10.3
 Measuring method



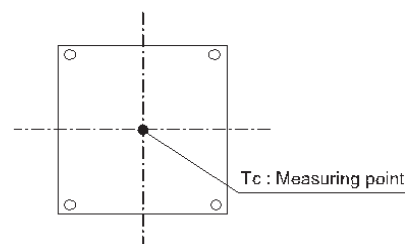
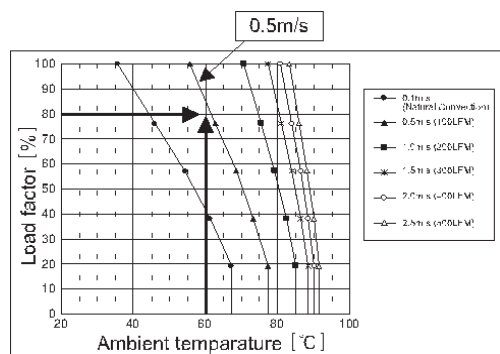
- Example of CBS504812

Conditions Load factor : 80 [%]
 Ambient temperature : 60 [°C]

Shown in Fig.8.10.4, it is necessary to keep the wind velocity more than 0.5m/s. Refer to 8.10.2 Thermal Curves. Keep the baseplate temperature is lower than its derating curve temperature. Refer to 8.6.1 Baseplate temperature.

Measure the baseplate temperature at the center of the baseplate

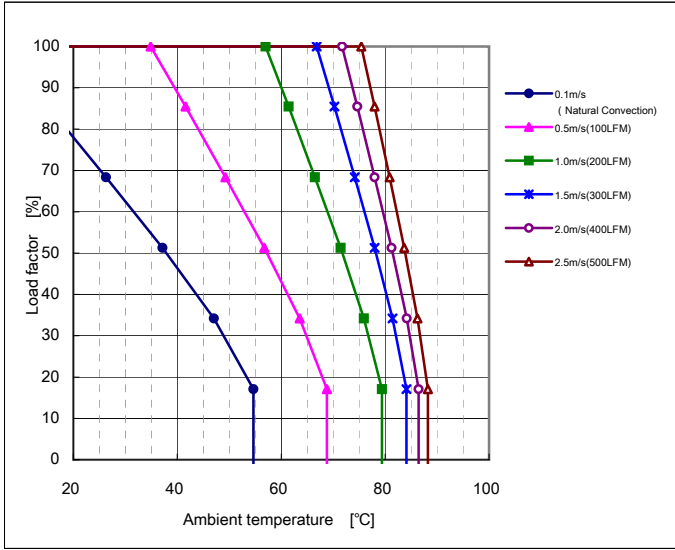
Fig.9.10.4
 Example of Thermal curves



Thermal Considerations

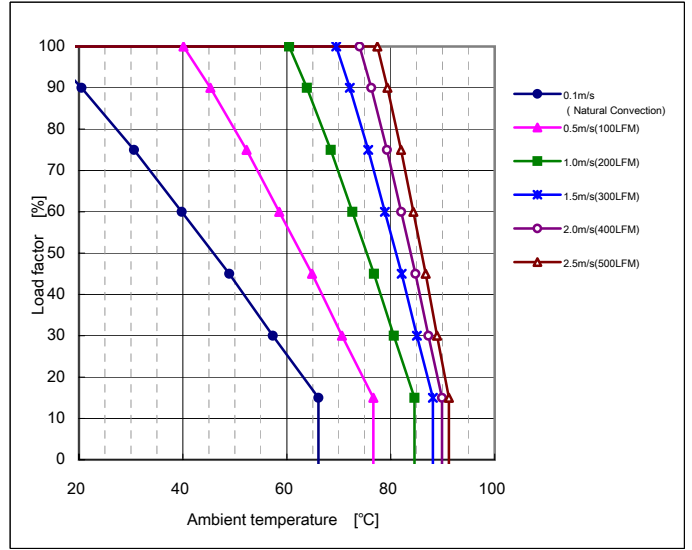
9.10.2 Thermal curves

CBS50xx03

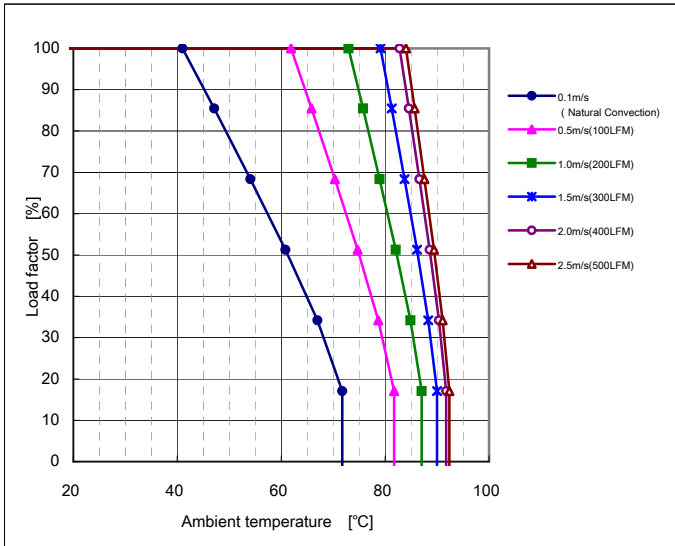


F-CBS-F1/F2 (H = 12.7mm)

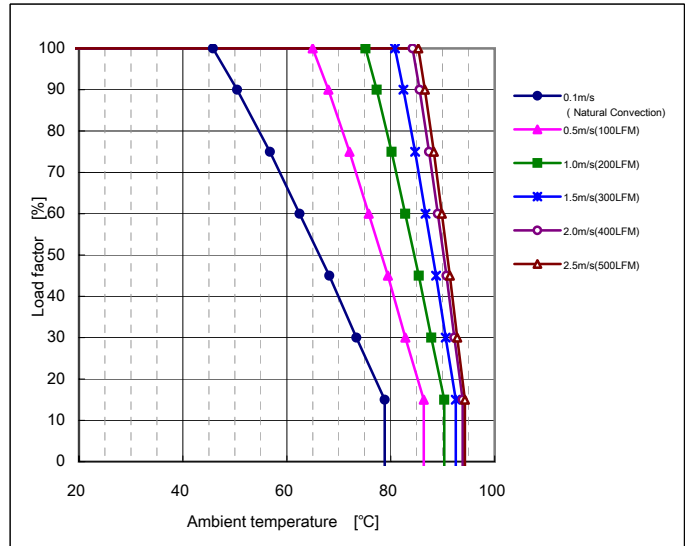
CBS50xx05



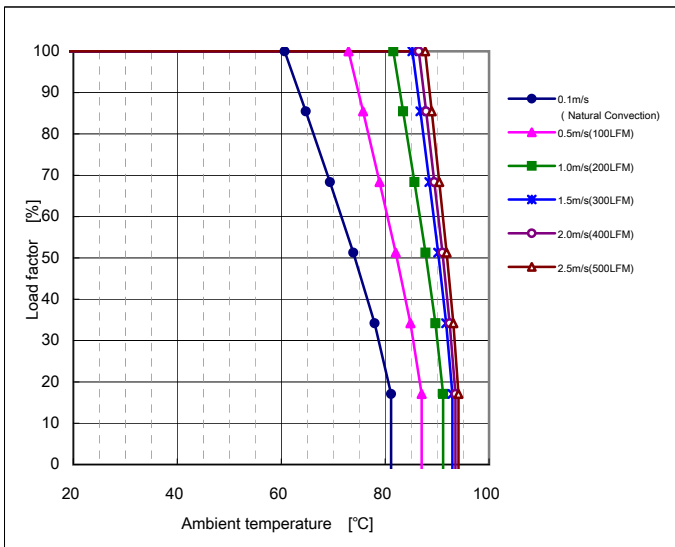
F-CBS-F1/F2 (H = 12.7mm)



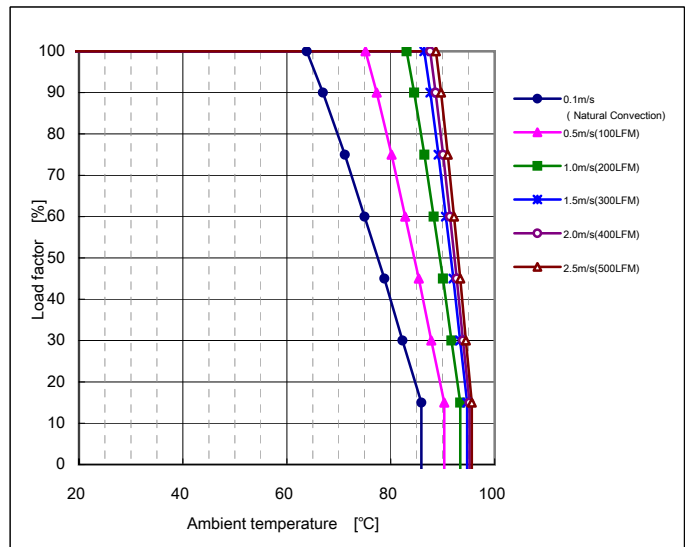
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



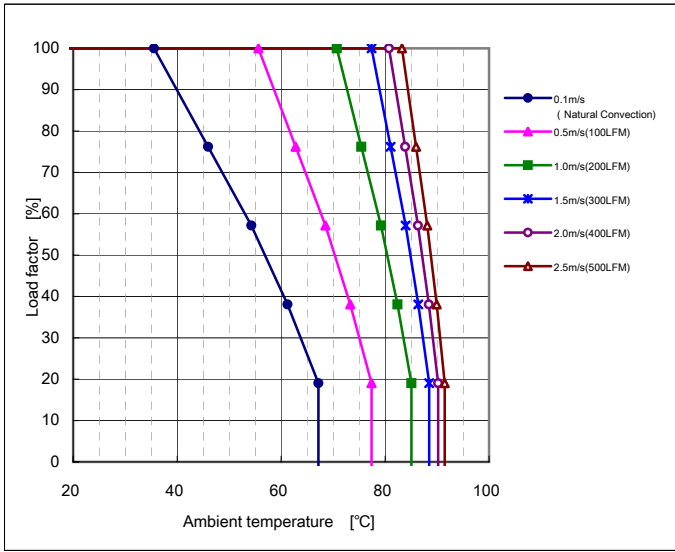
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

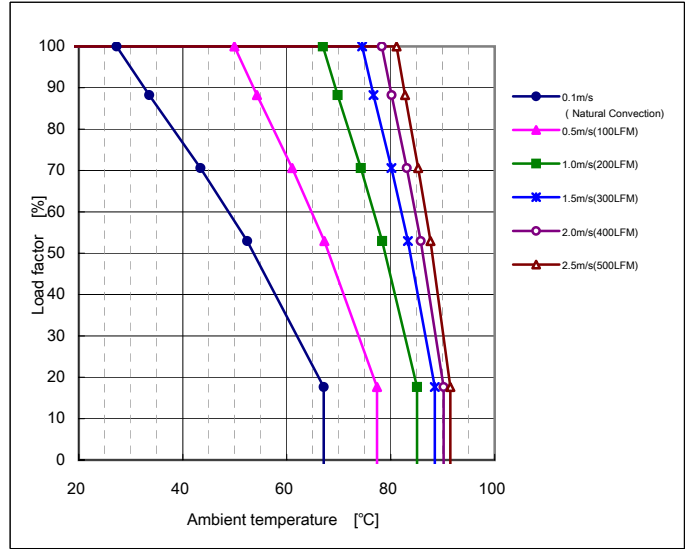
Thermal Considerations

CBS50xx12

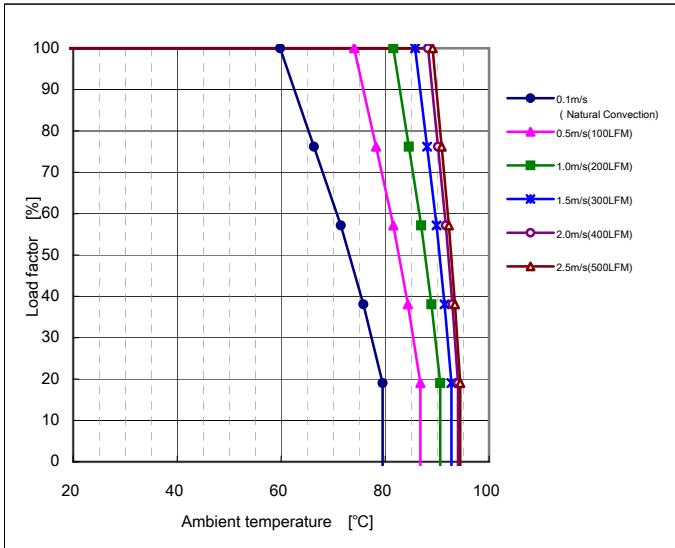


F-CBS-F1/F2 (H = 12.7mm)

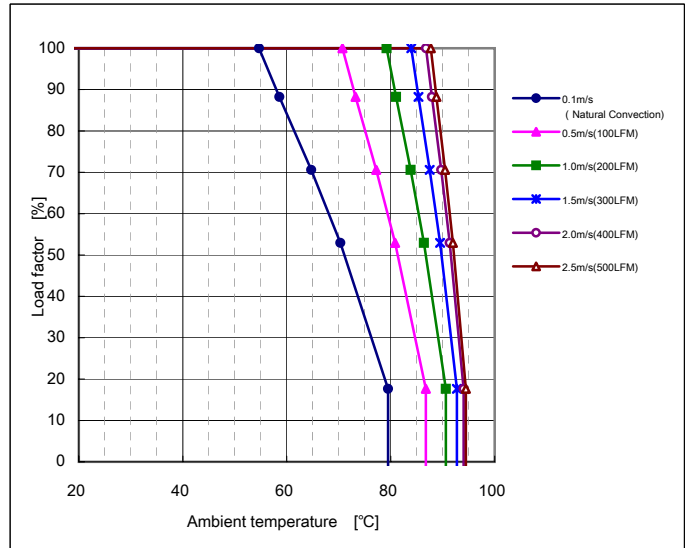
CBS50xx15



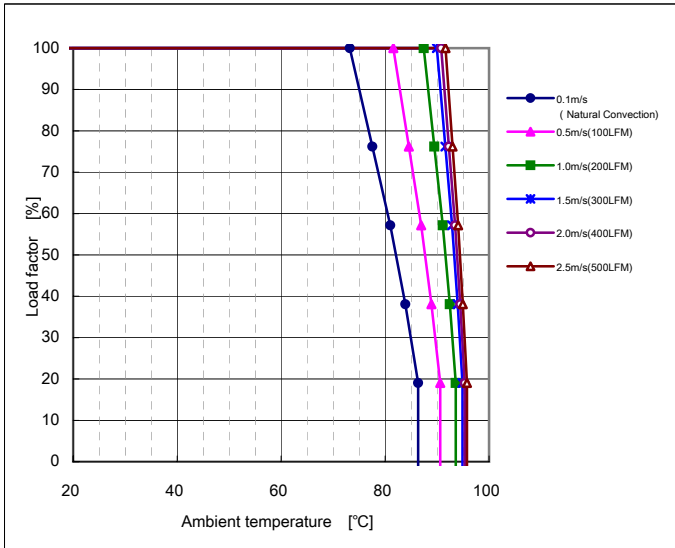
F-CBS-F1/F2 (H = 12.7mm)



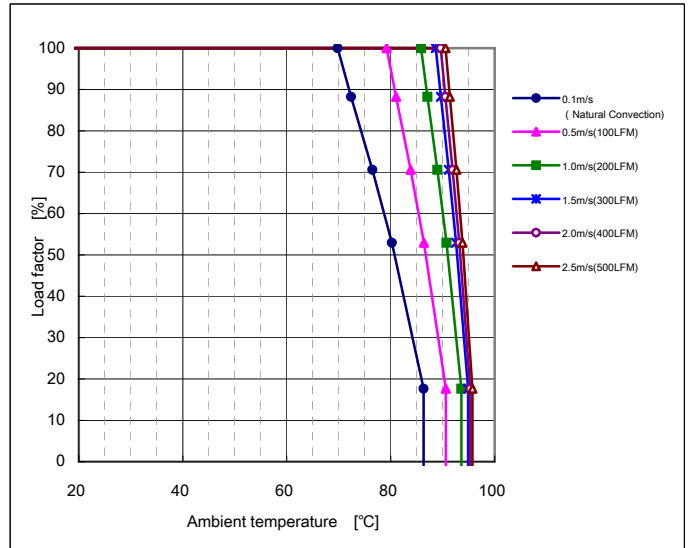
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



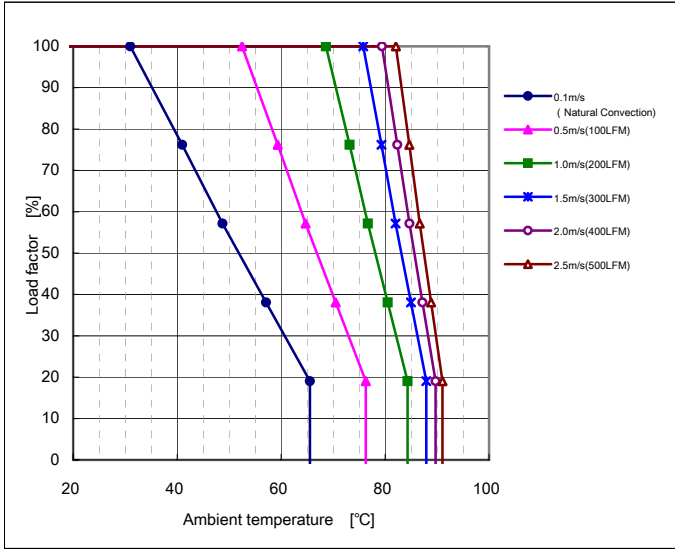
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

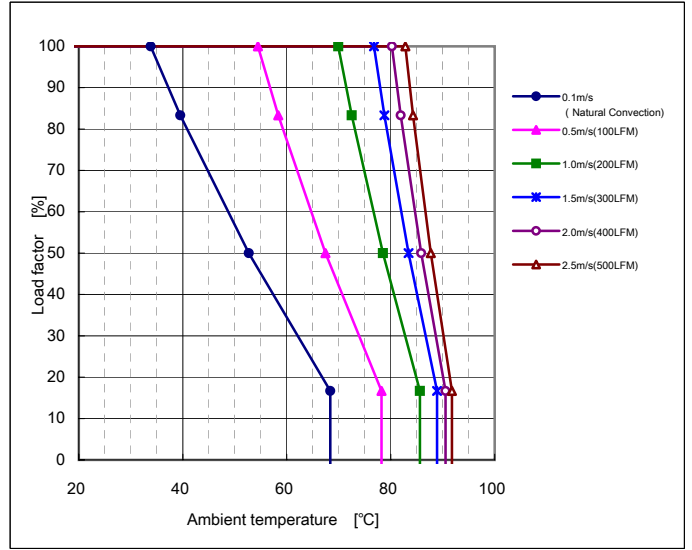
Thermal Considerations

CBS50xx24

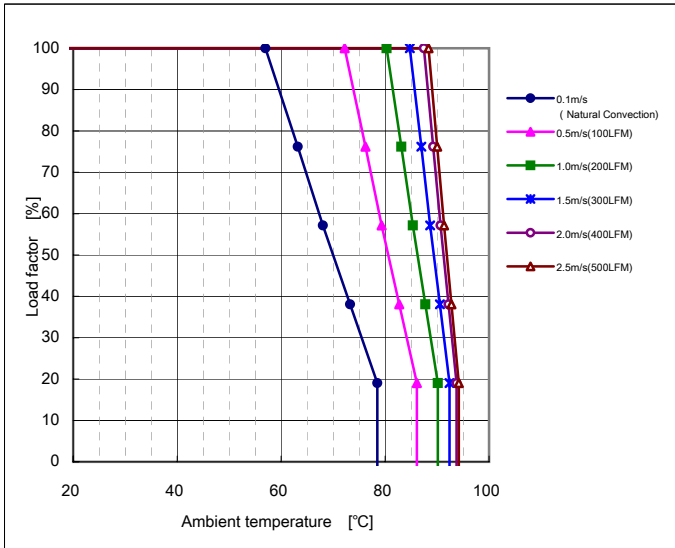


F-CBS-F1/F2 (H = 12.7mm)

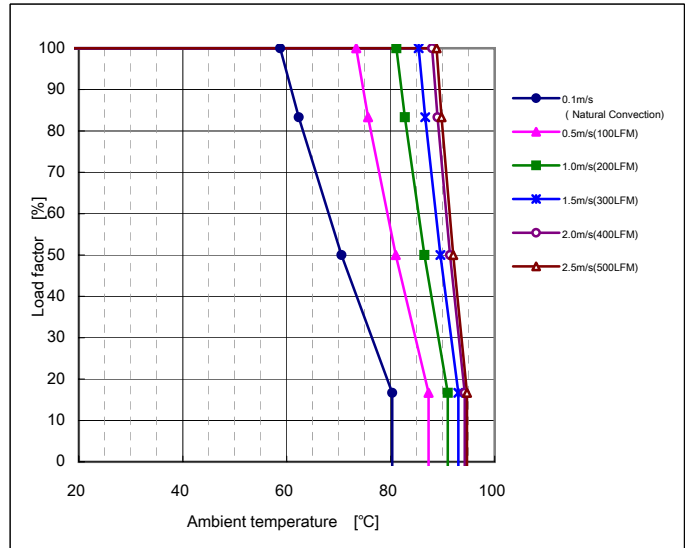
CBS50xx28



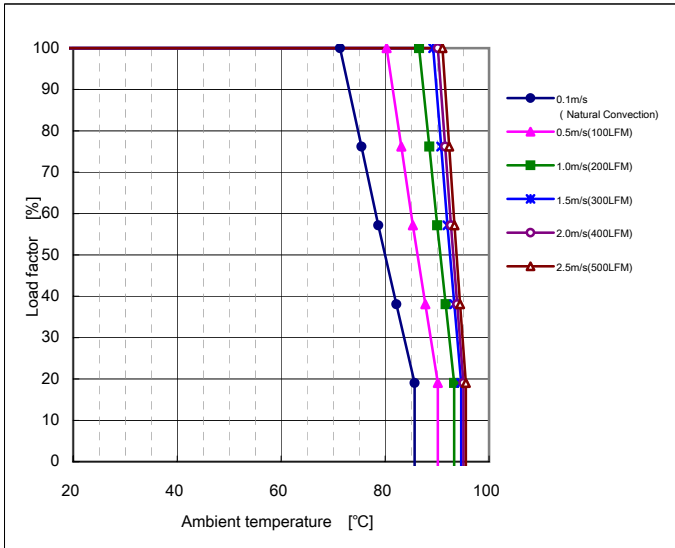
F-CBS-F1/F2 (H = 12.7mm)



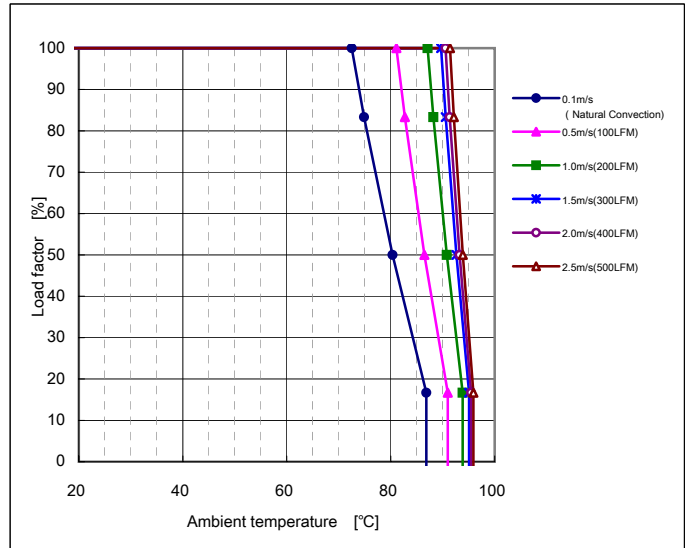
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



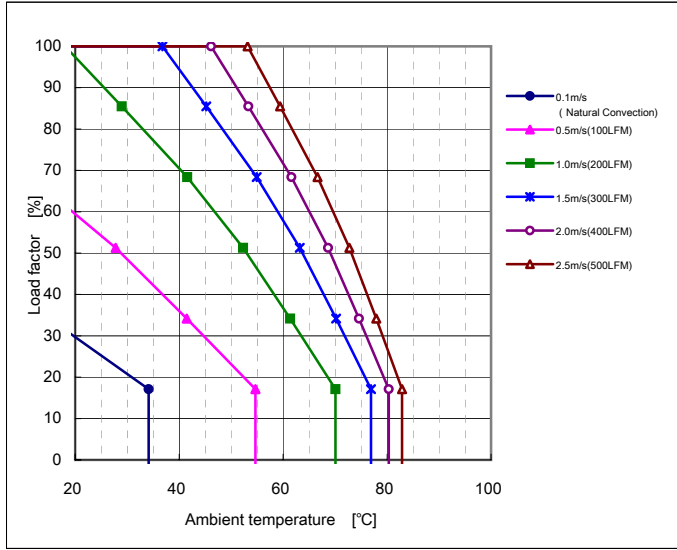
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

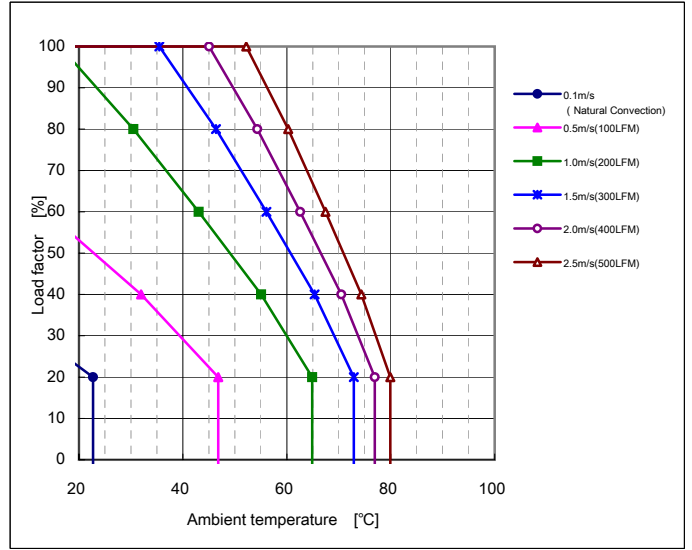
Thermal Considerations

CBS100xx03

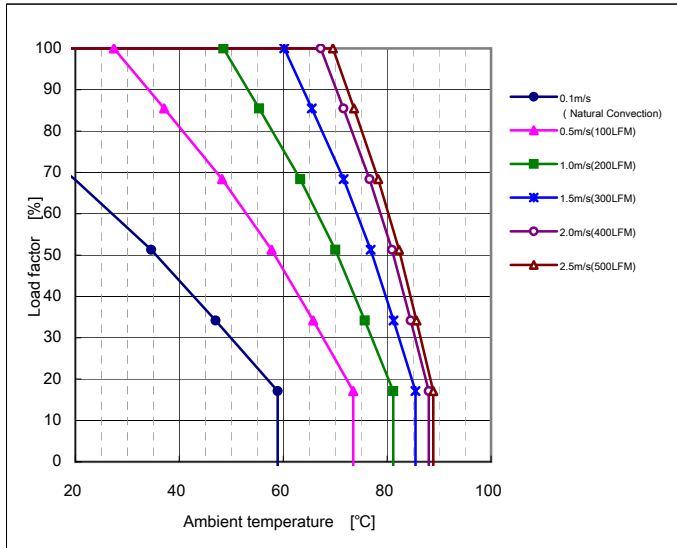


F-CBS-F1/F2 (H = 12.7mm)

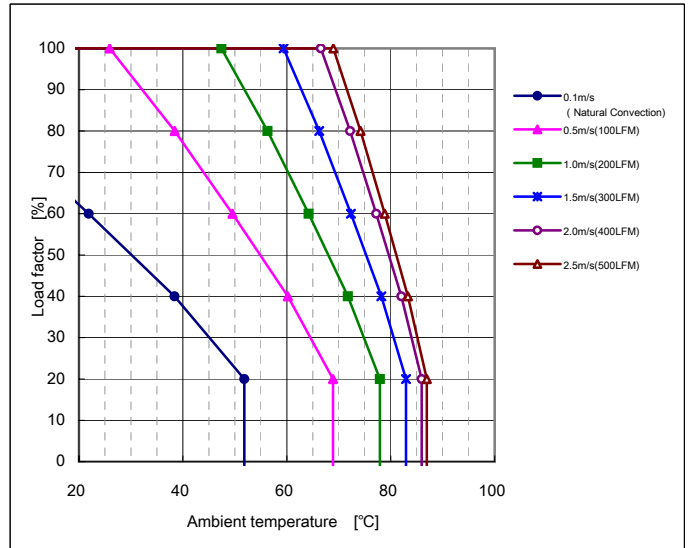
CBS100xx05



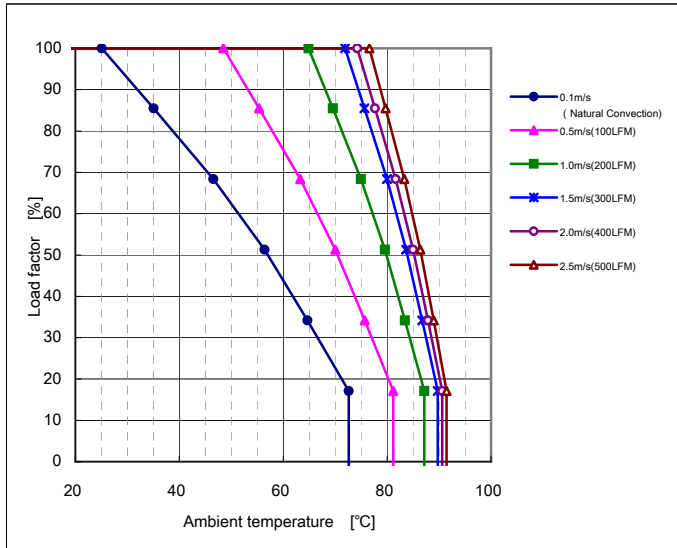
F-CBS-F1/F2 (H = 12.7mm)



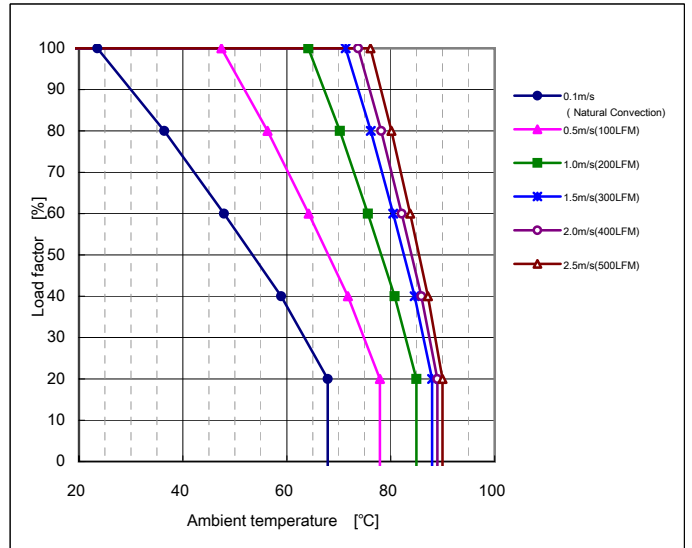
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



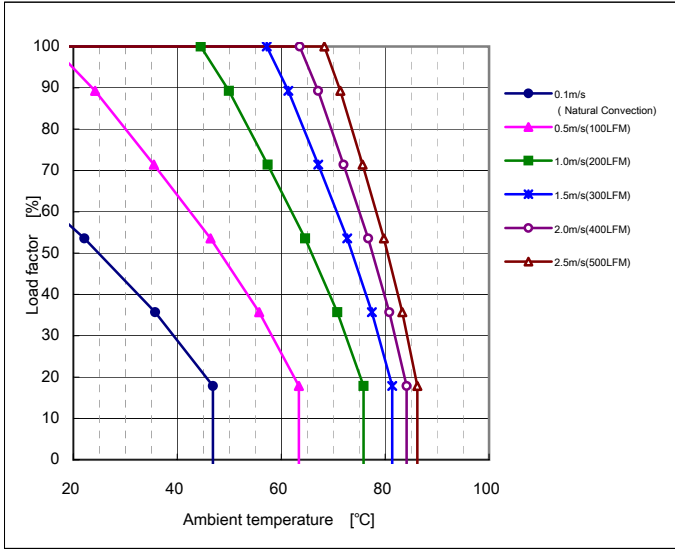
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

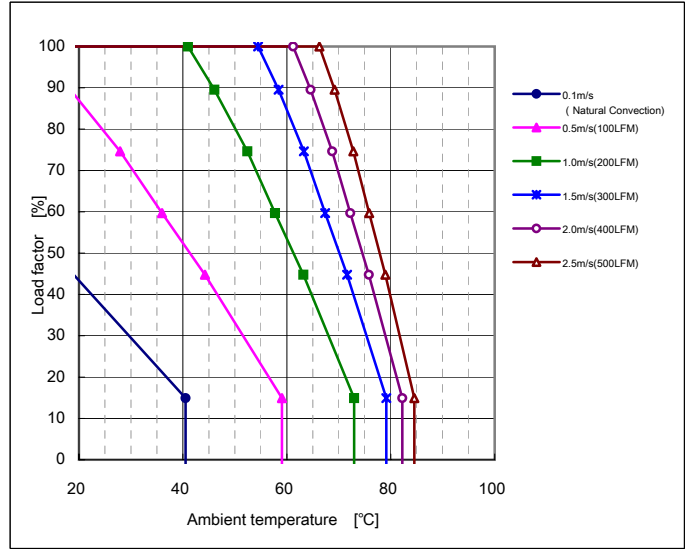
Thermal Considerations

CBS100xx12

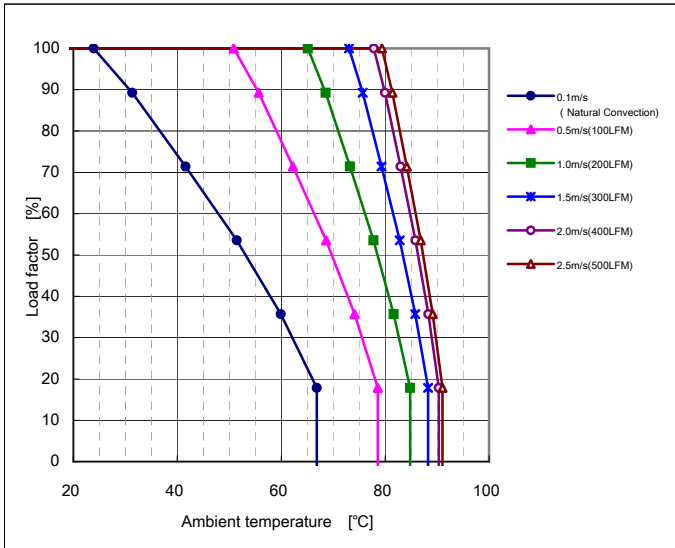


F-CBS-F1/F2 (H = 12.7mm)

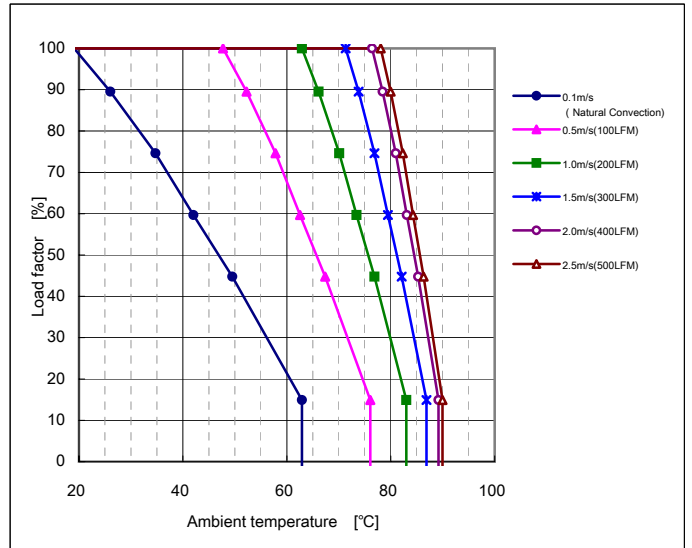
CBS100xx15



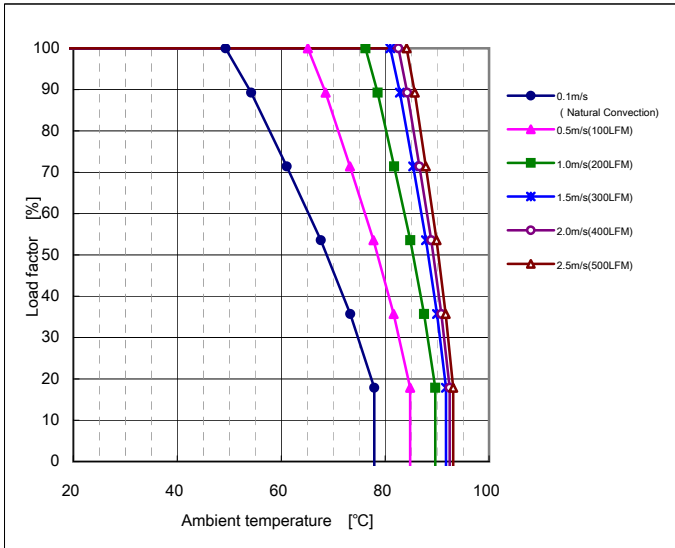
F-CBS-F1/F2 (H = 12.7mm)



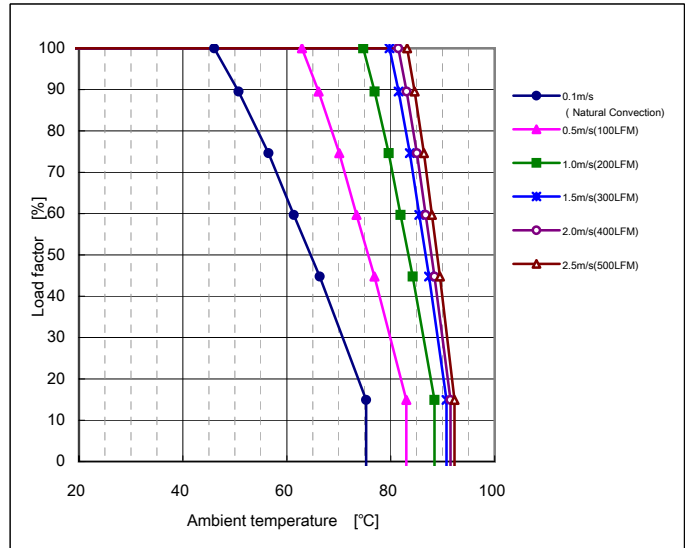
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



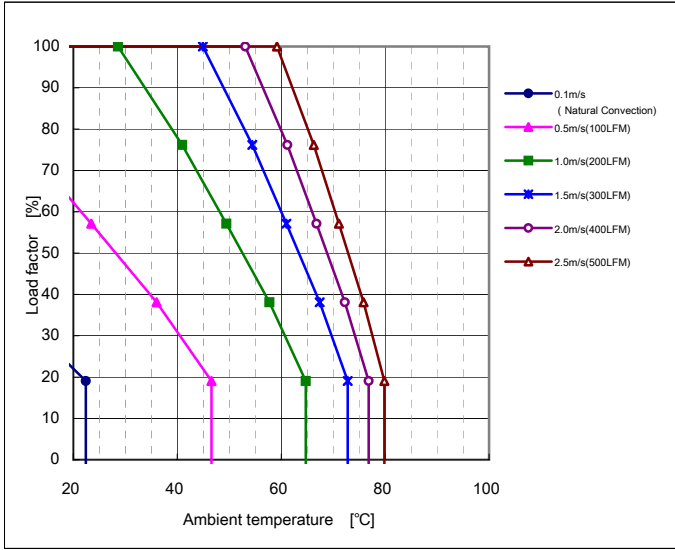
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

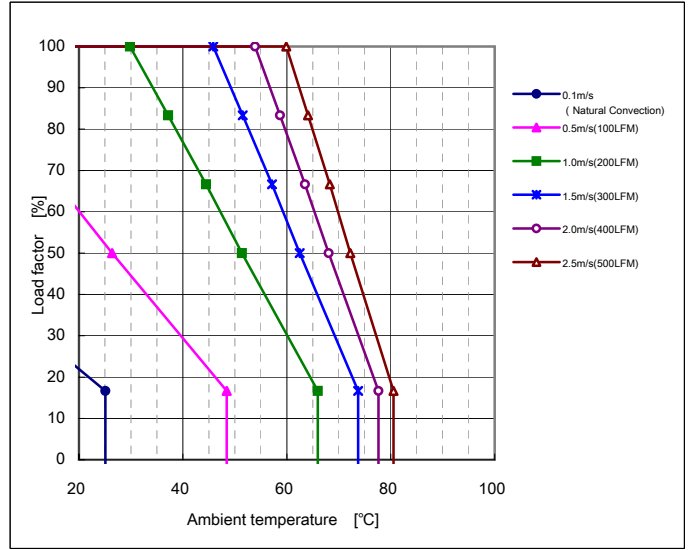
Thermal Considerations

CBS100xx24

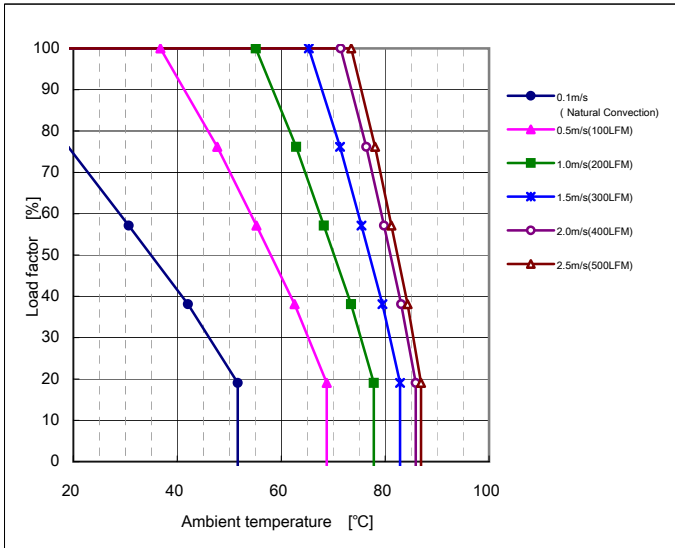


F-CBS-F1/F2 (H = 12.7mm)

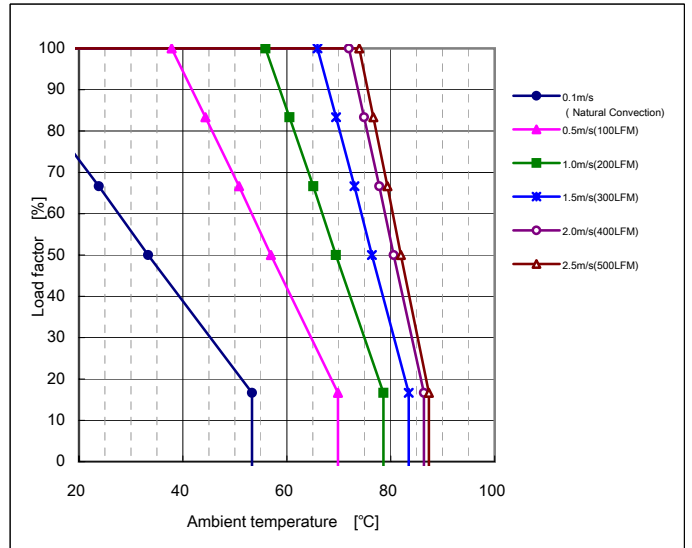
CBS100xx28



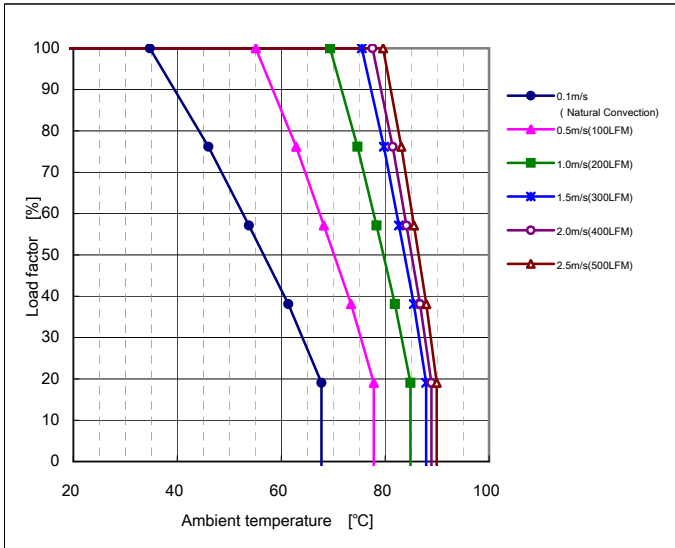
F-CBS-F1/F2 (H = 12.7mm)



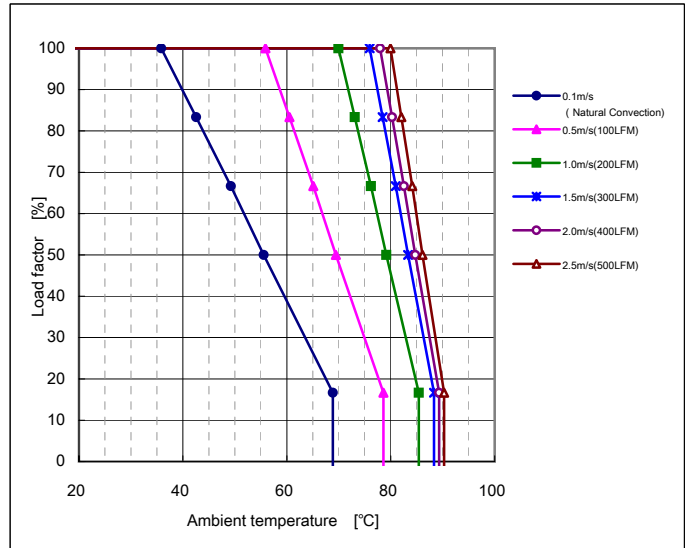
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



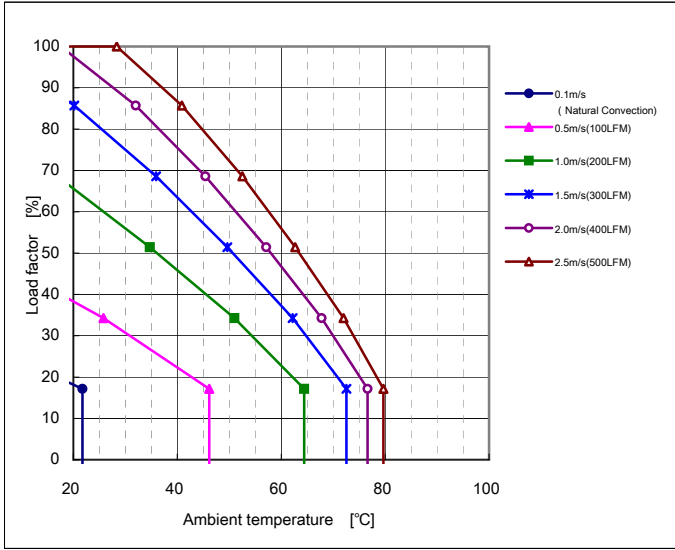
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

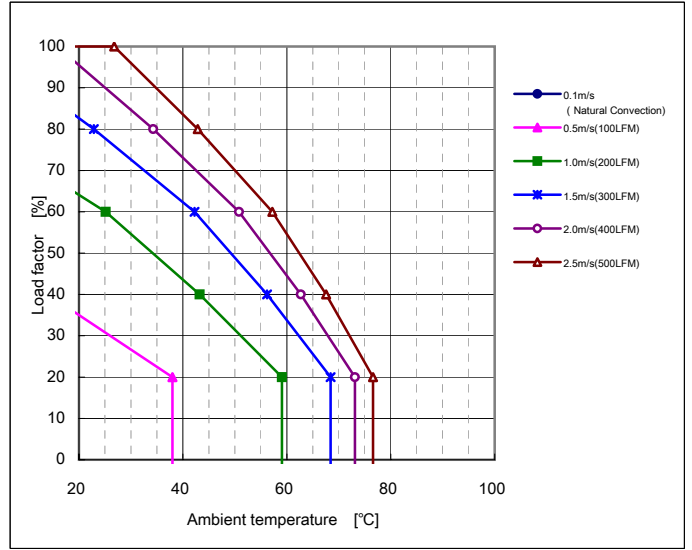
Thermal Considerations

CBS200xx03

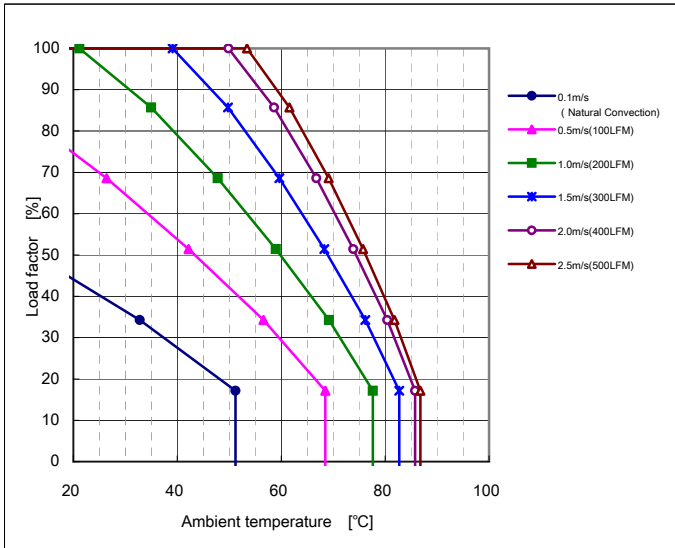


F-CBS-F1/F2 (H = 12.7mm)

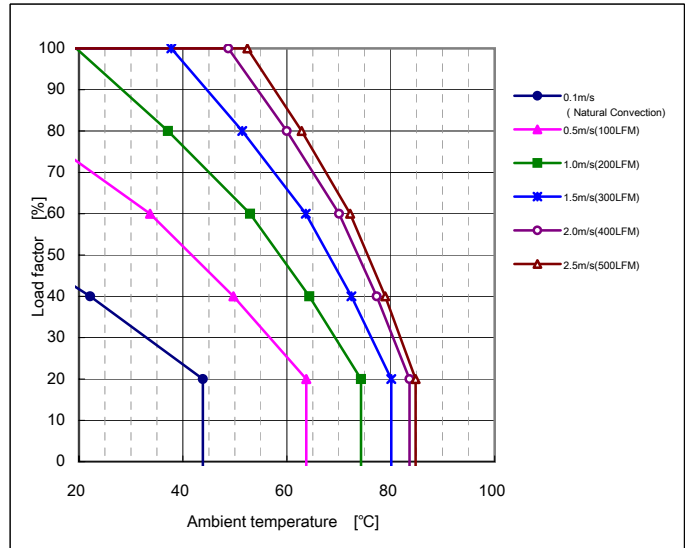
CBS200xx05



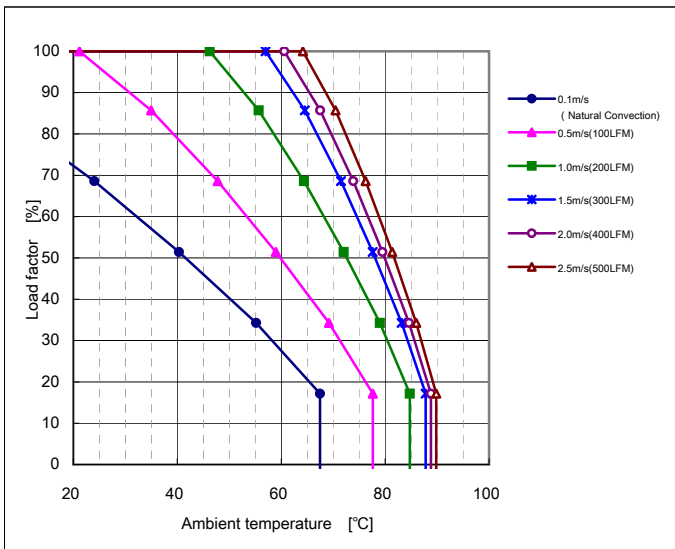
F-CBS-F1/F2 (H = 12.7mm)



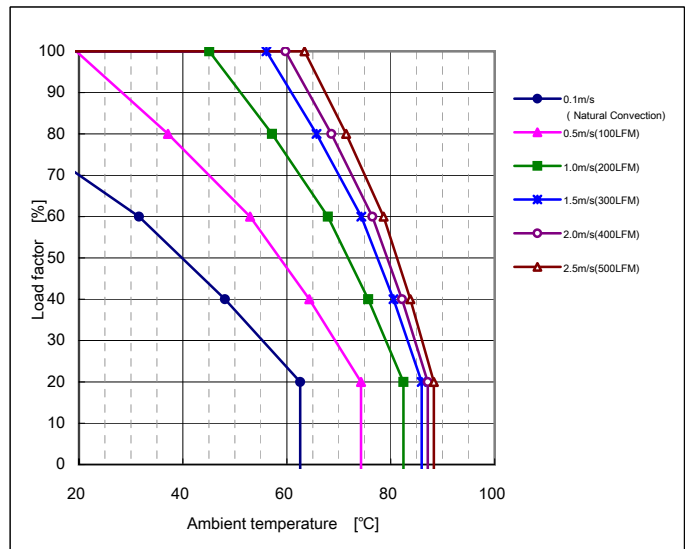
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



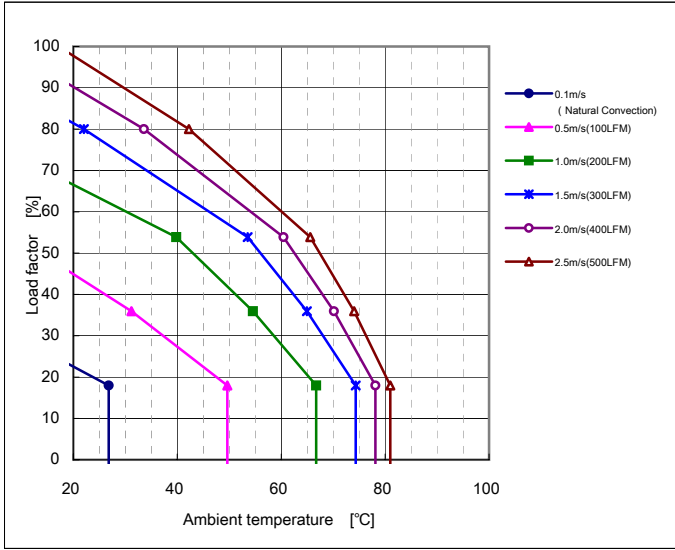
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

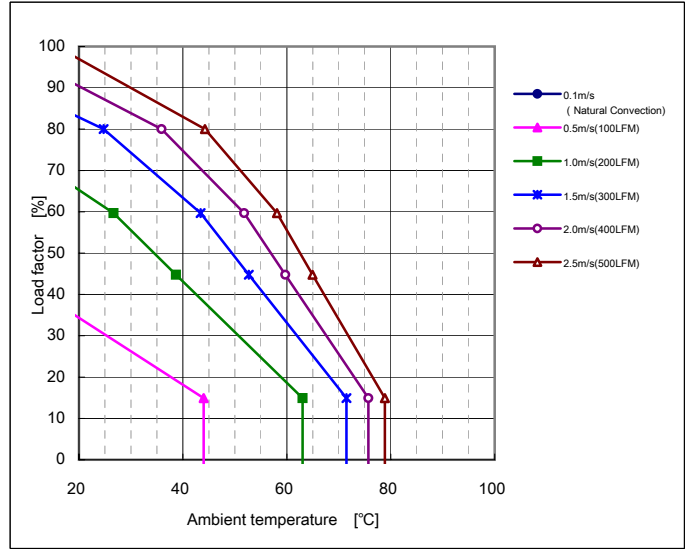
Thermal Considerations

CBS200xx12

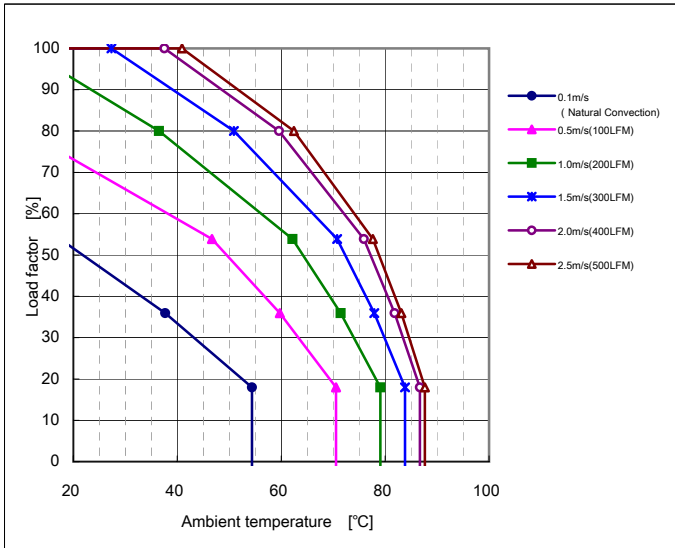


F-CBS-F1/F2 (H = 12.7mm)

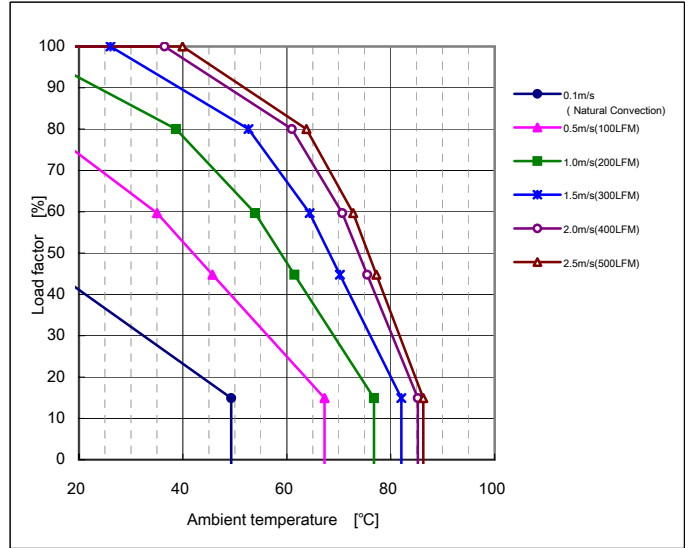
CBS200xx15



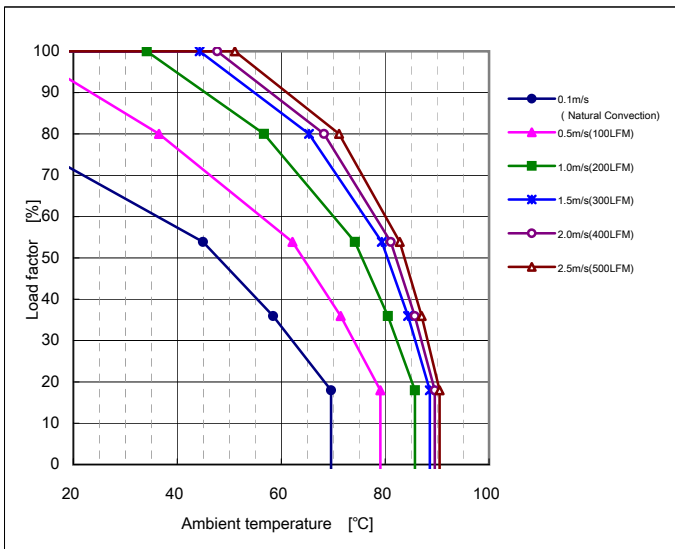
F-CBS-F1/F2 (H = 12.7mm)



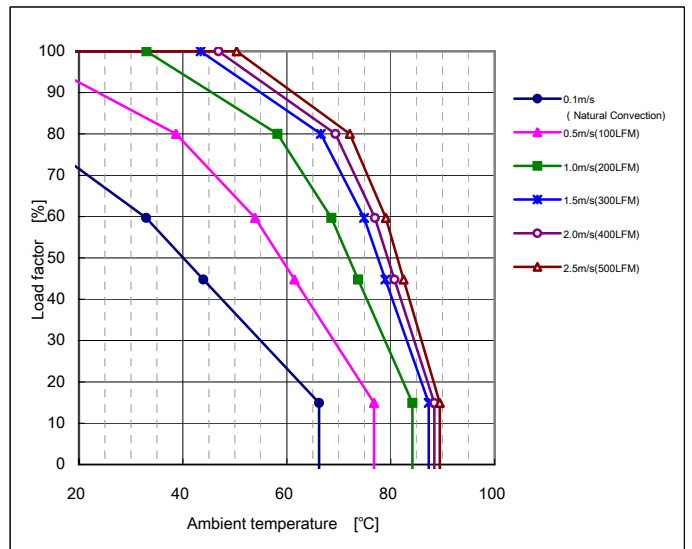
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



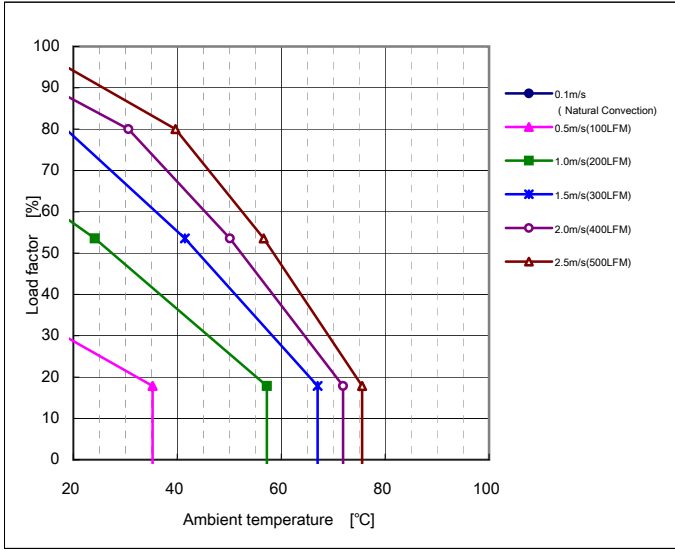
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

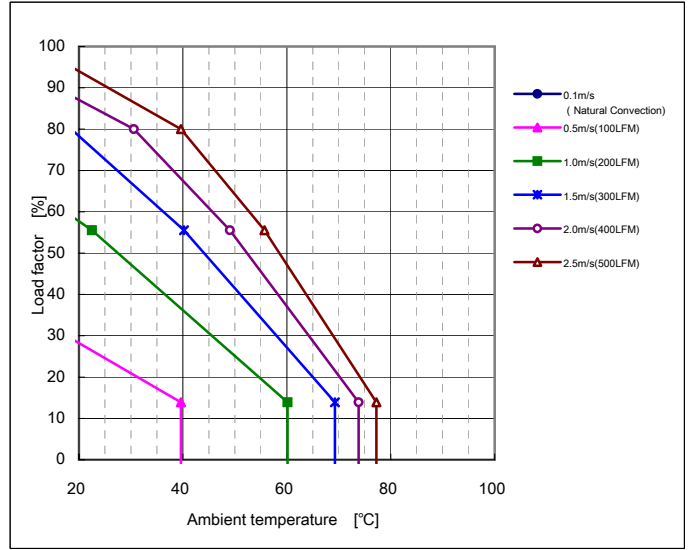
Thermal Considerations

CBS200xx24

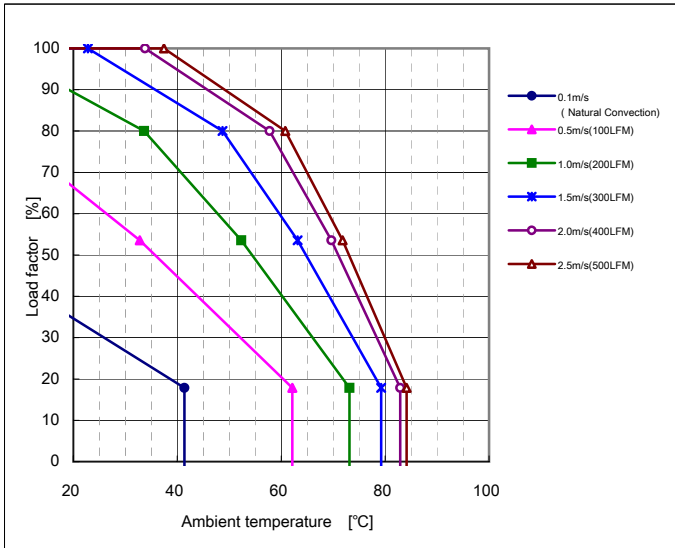


F-CBS-F1/F2 (H = 12.7mm)

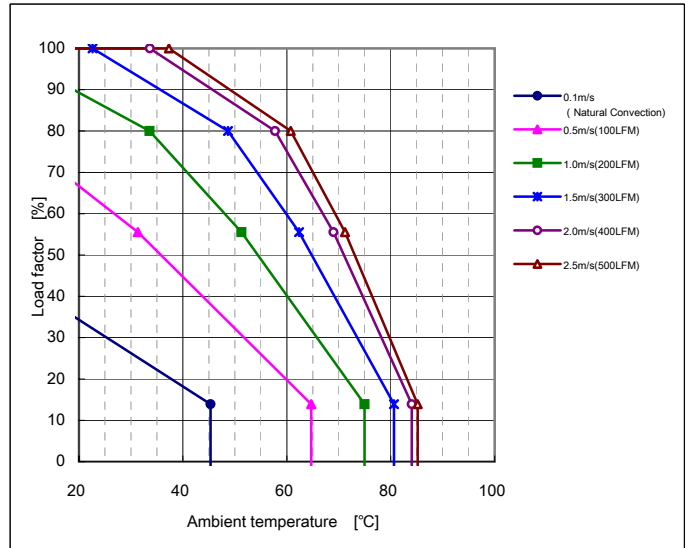
CBS200xx28



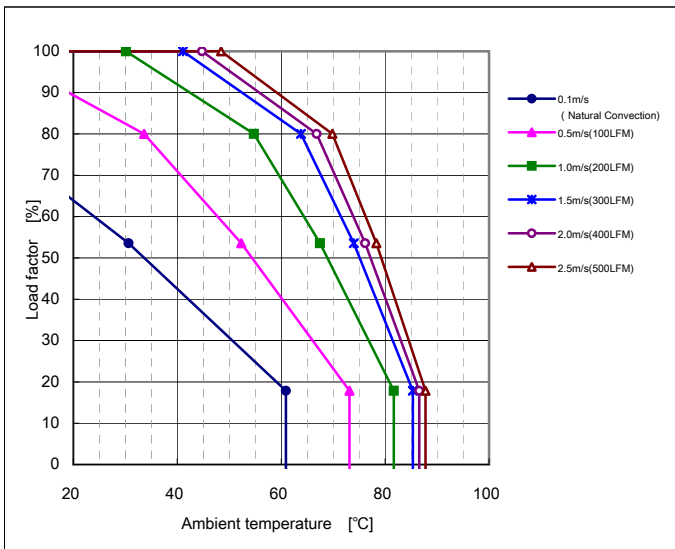
F-CBS-F1/F2 (H = 12.7mm)



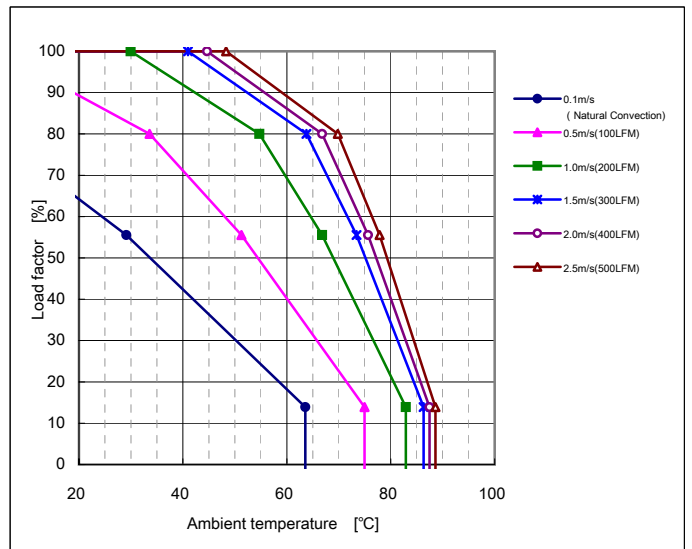
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



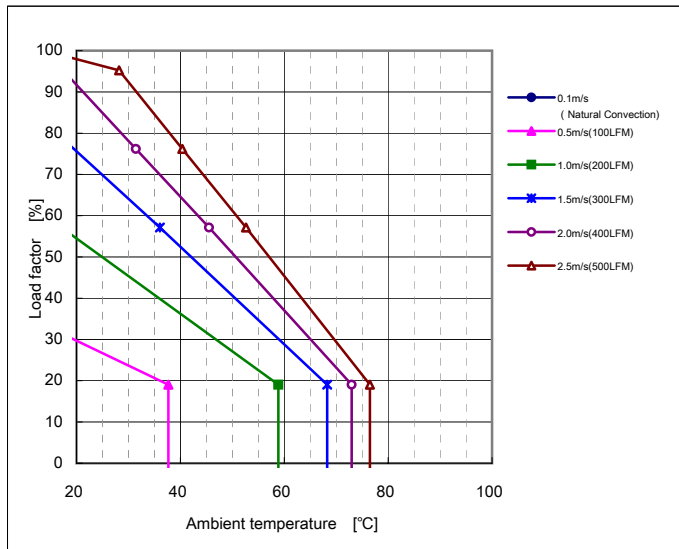
F-CBS-F5/F6 (H = 38.1mm)



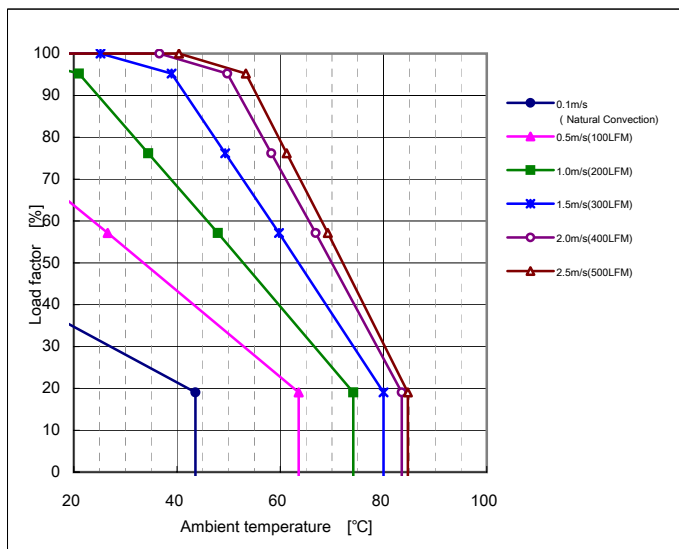
F-CBS-F5/F6 (H = 38.1mm)

Thermal Considerations

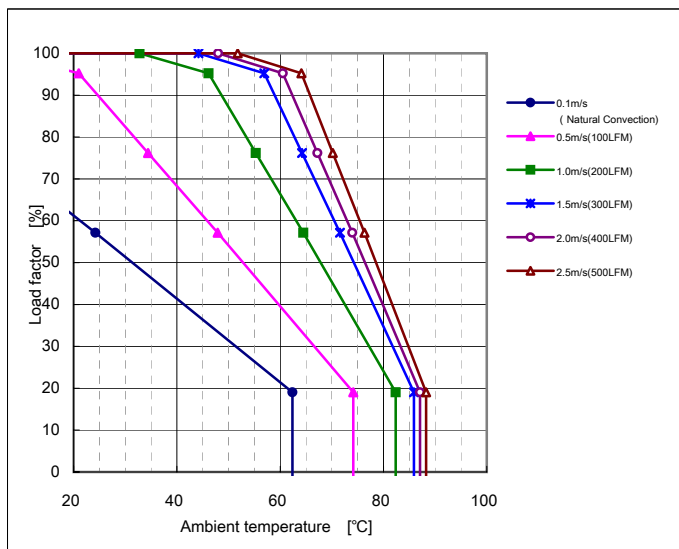
CBS2004848



F-CBS-F1/F2 (H = 12.7mm)



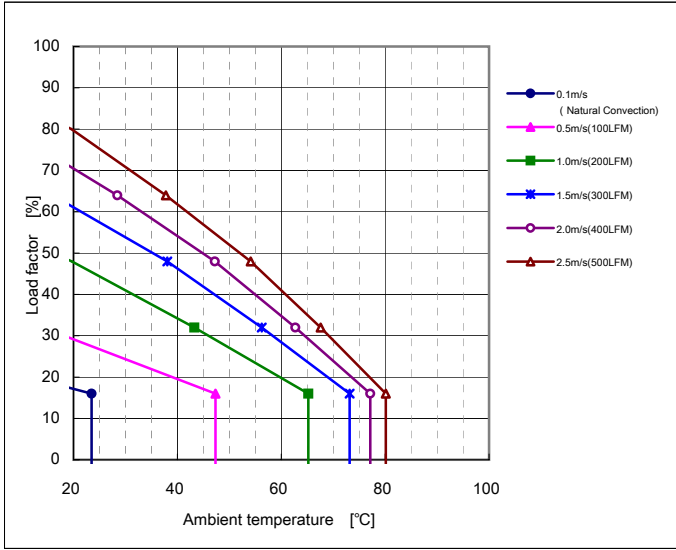
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F5/F6 (H = 38.1mm)

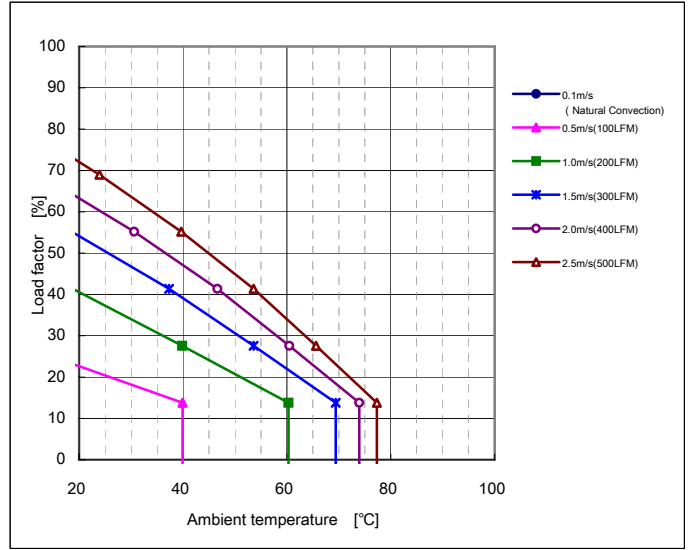
Thermal Considerations

CBS3502412

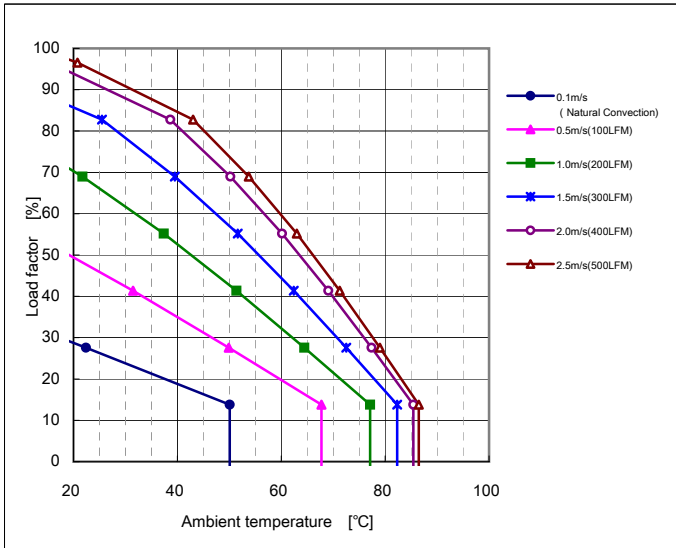


F-CBS-F1/F2 (H = 12.7mm)

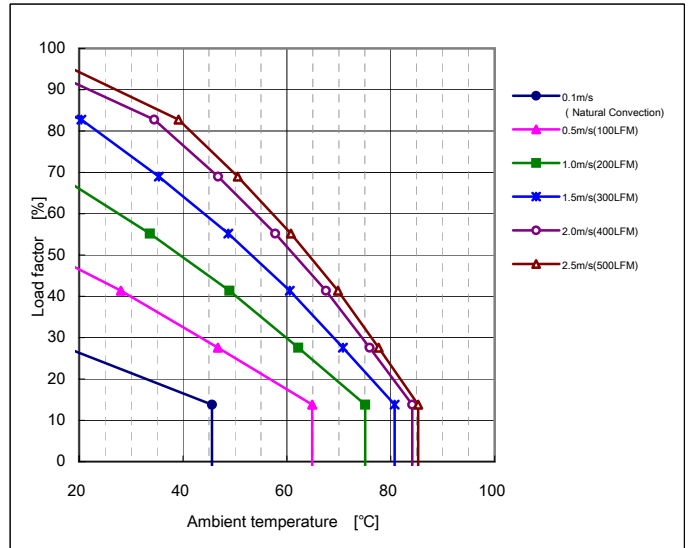
CBS3504812



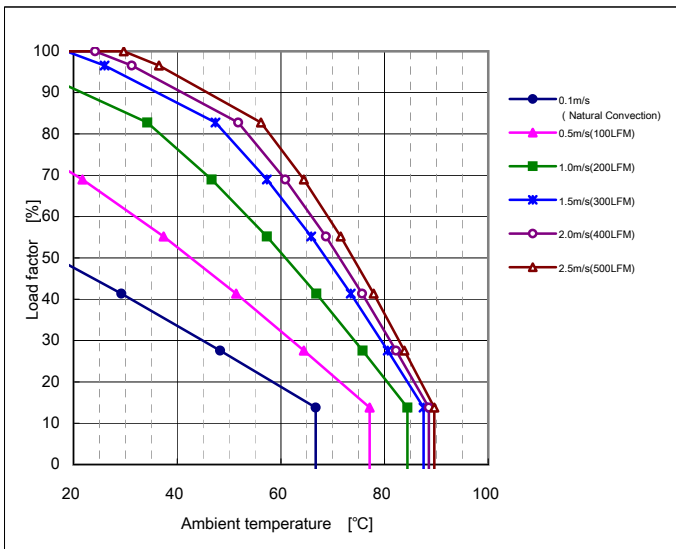
F-CBS-F1/F2 (H = 12.7mm)



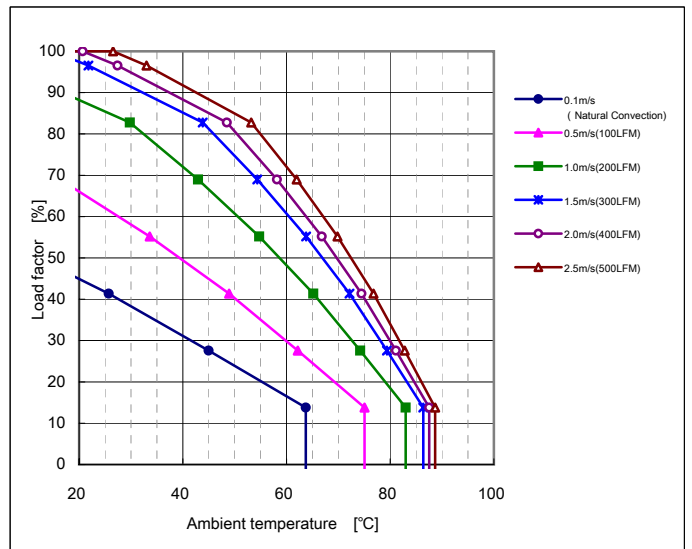
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



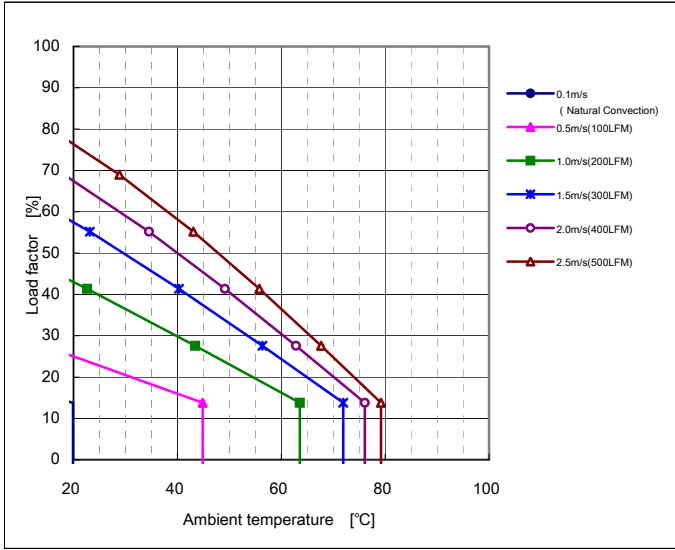
F-CBS-F5/F6 (H = 38.1mm)



F-CBS-F5/F6 (H = 38.1mm)

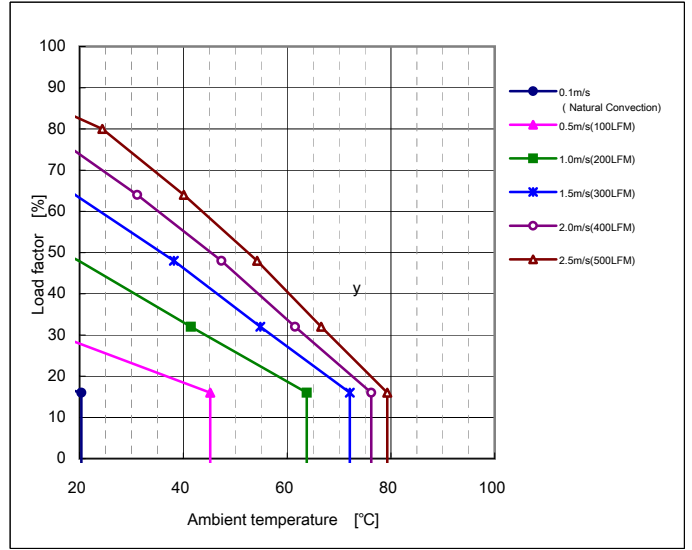
Thermal Considerations

CBS350xx24

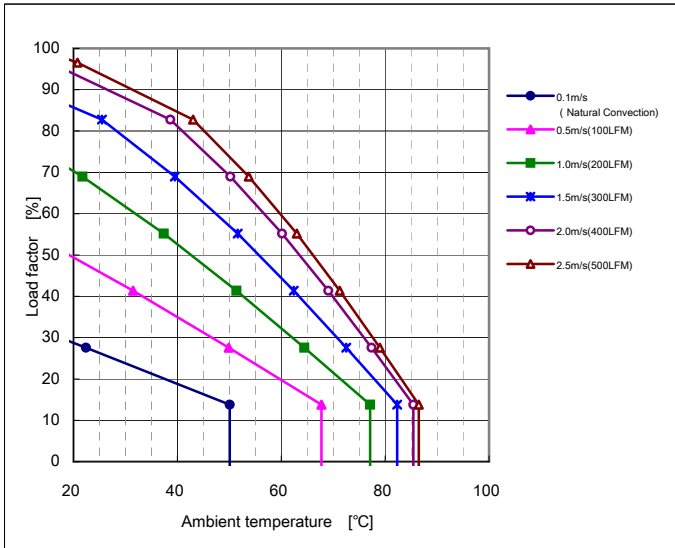


F-CBS-F1/F2 (H = 12.7mm)

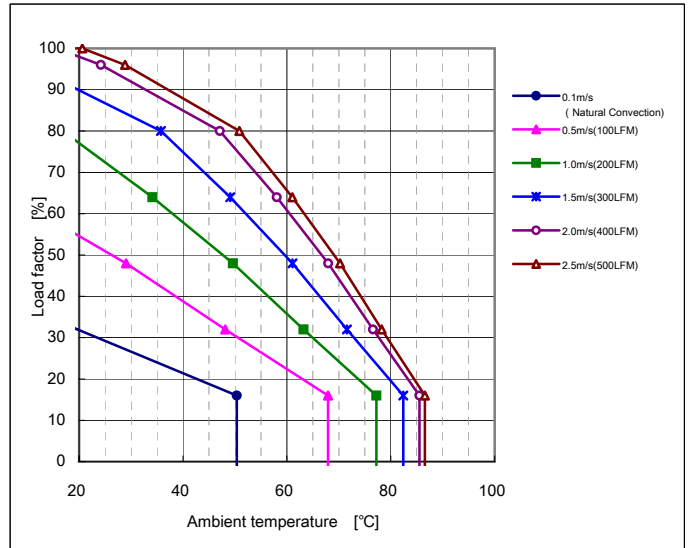
CBS350xx28



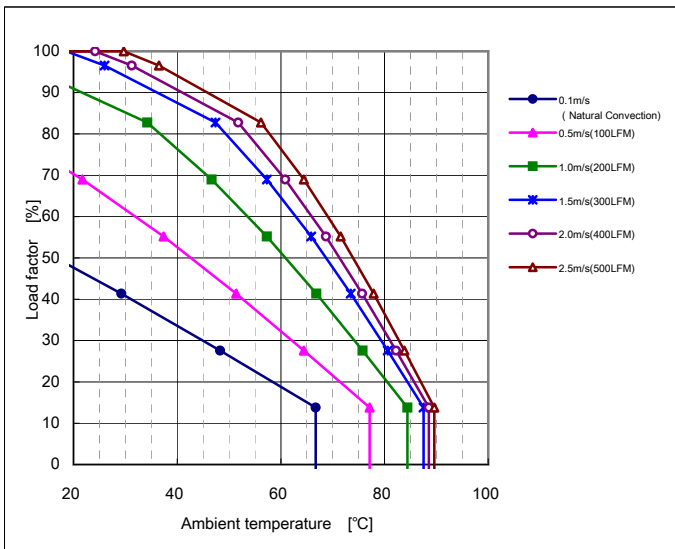
F-CBS-F1/F2 (H = 12.7mm)



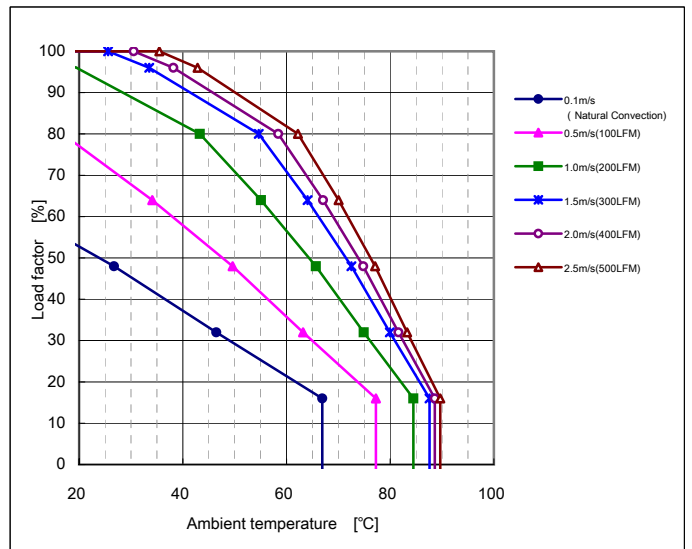
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F3/F4 (H = 25.4mm)



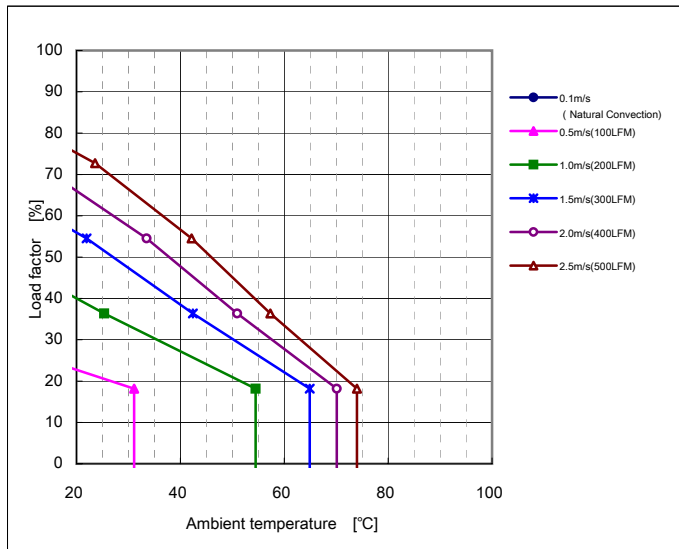
F-CBS-F5/F6 (H = 38.1mm)



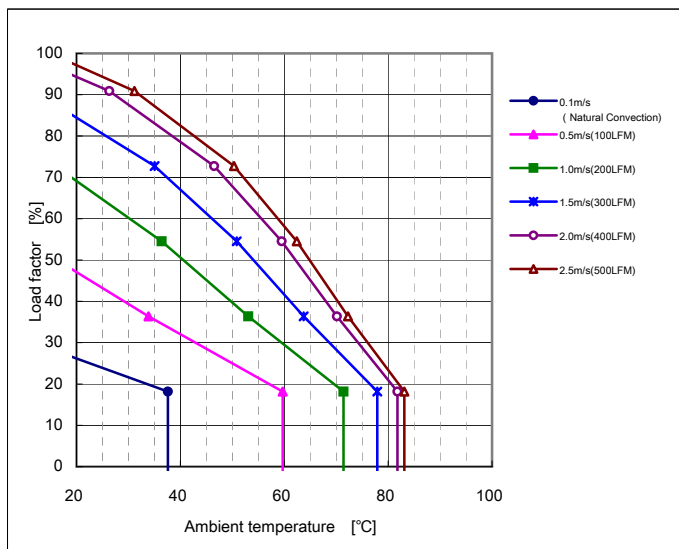
F-CBS-F5/F6 (H = 38.1mm)

Thermal Considerations

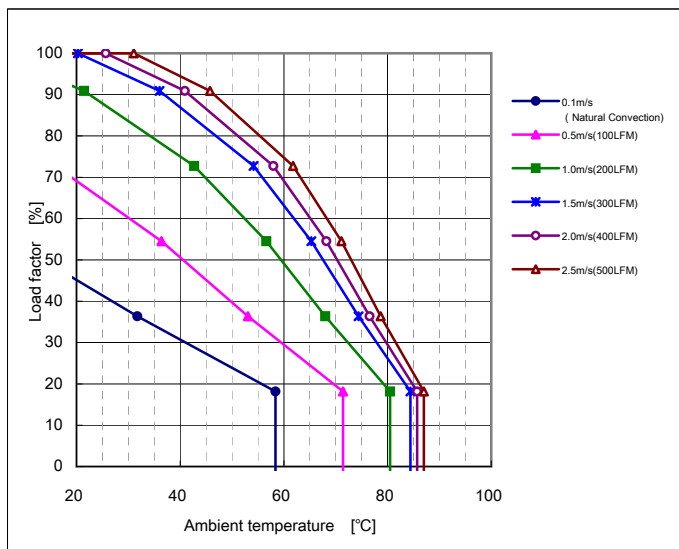
CBS350xx32



F-CBS-F1/F2 (H = 12.7mm)



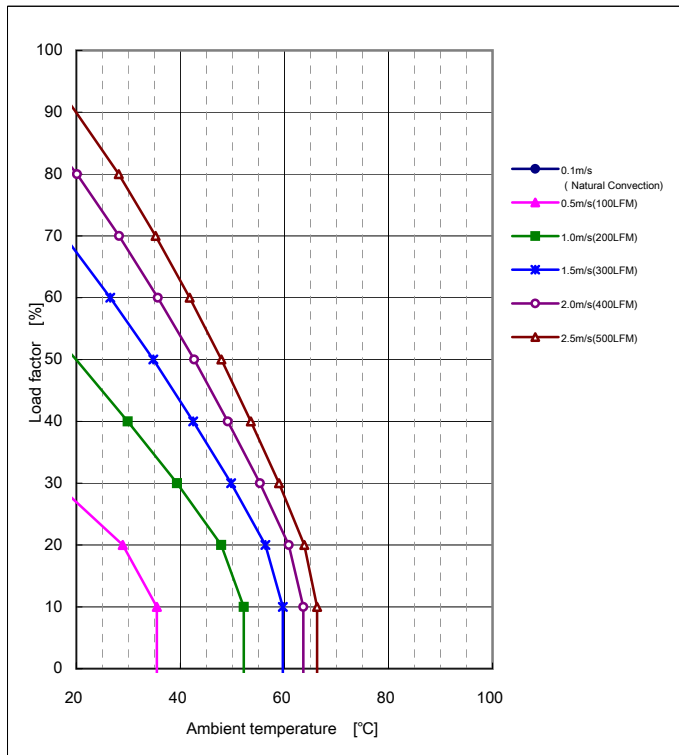
F-CBS-F3/F4 (H = 25.4mm)



F-CBS-F5/F6 (H = 38.1mm)

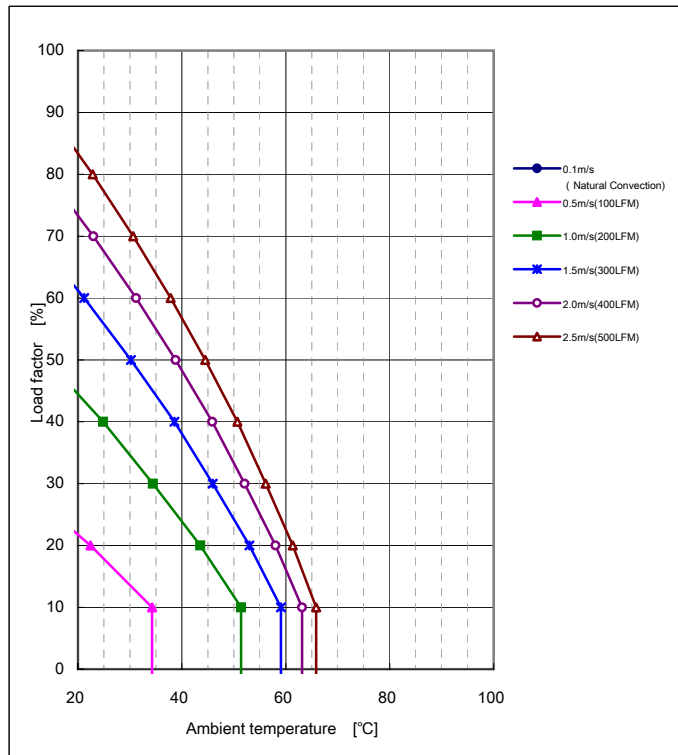
Thermal Considerations

CDS4004802

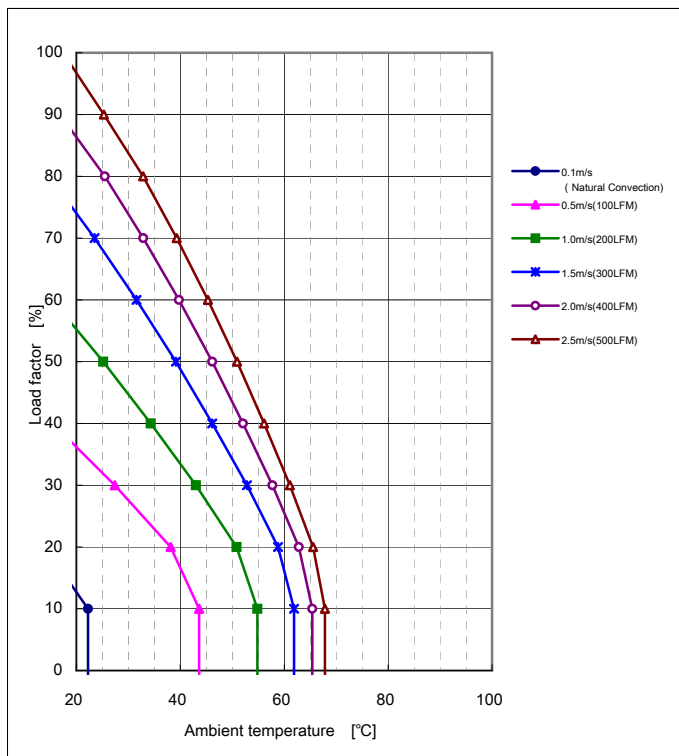


Heatsink A

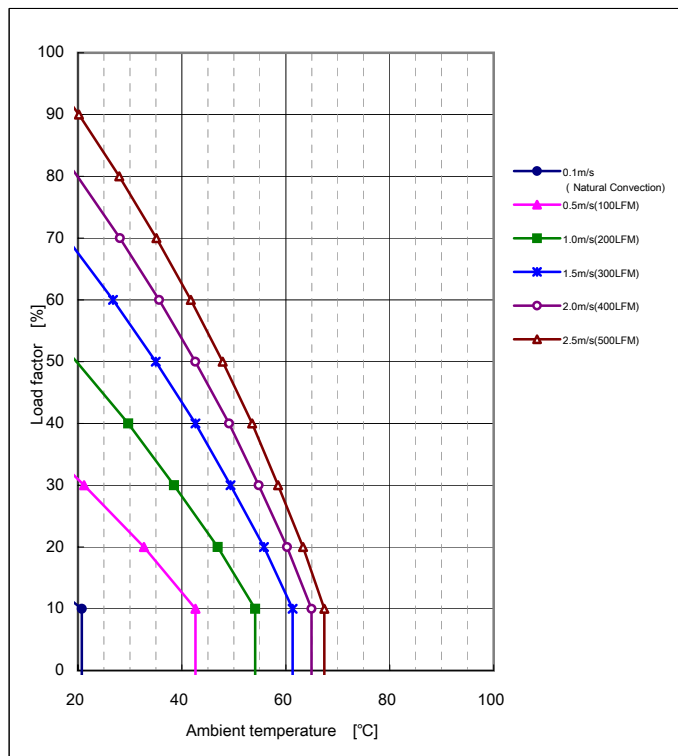
CDS4004803



Heatsink A



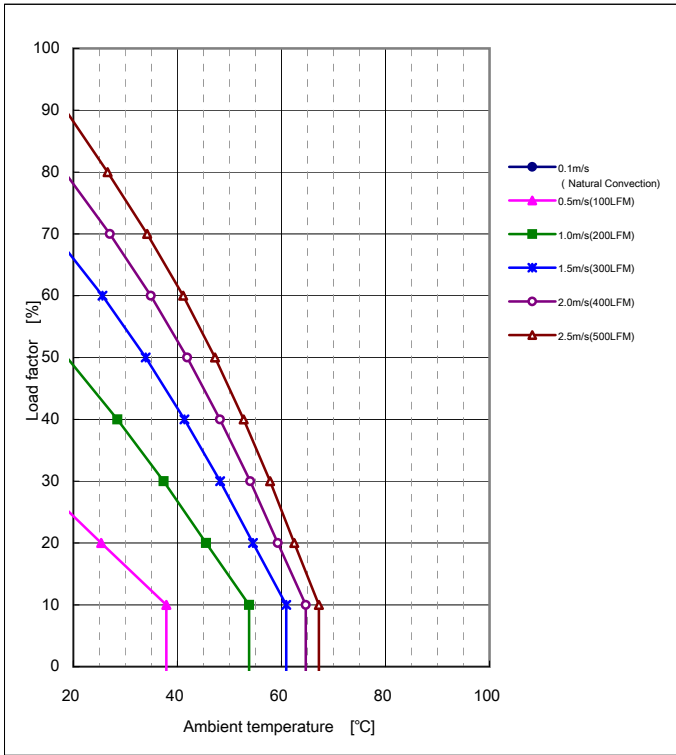
Heatsink B



Heatsink B

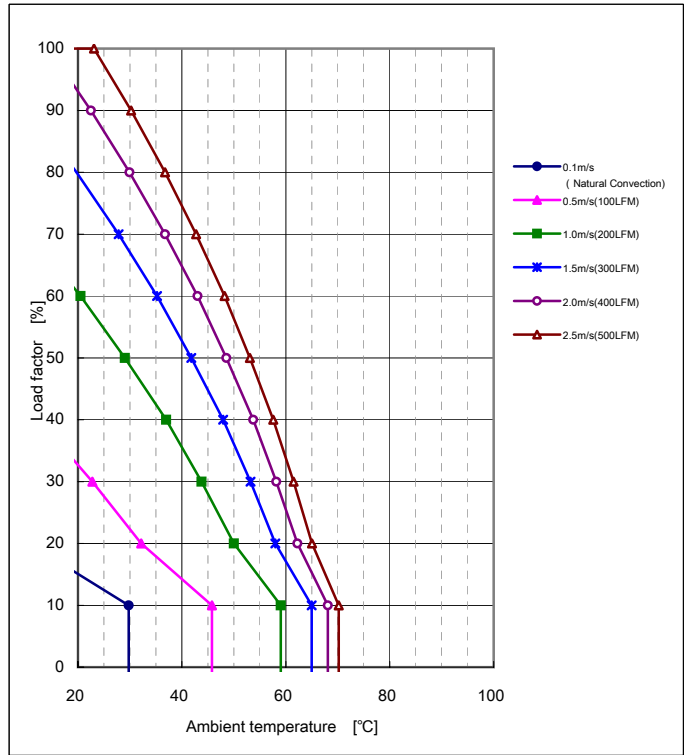
Thermal Considerations

CDS4004805

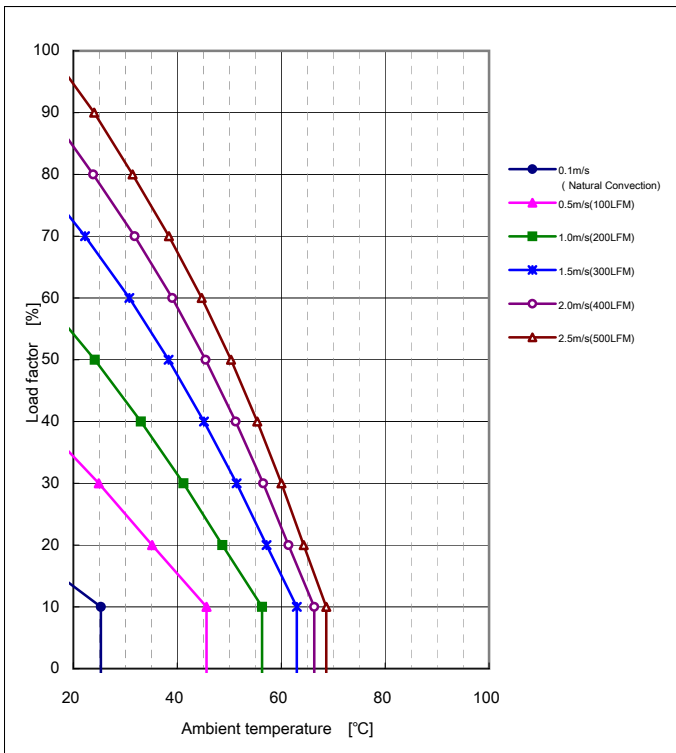


Heatsink A

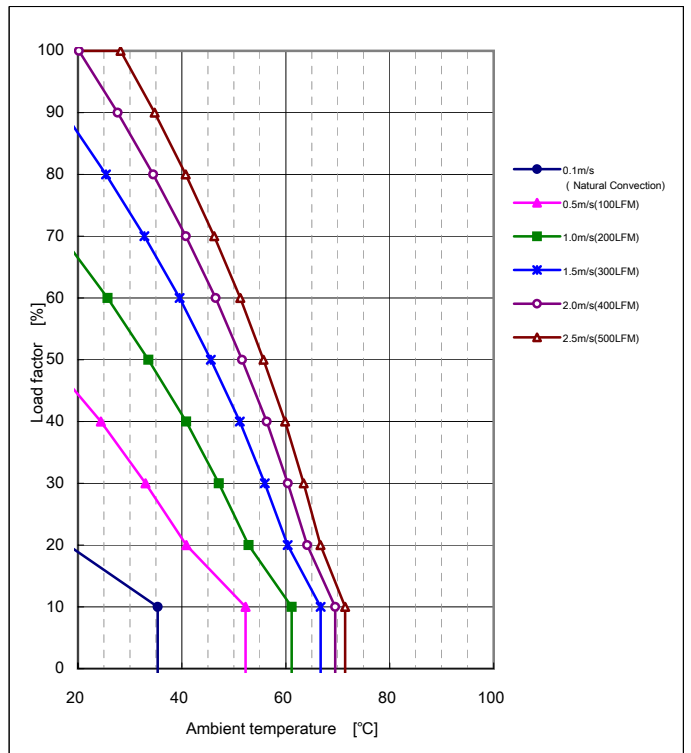
CDS4004807



Heatsink A



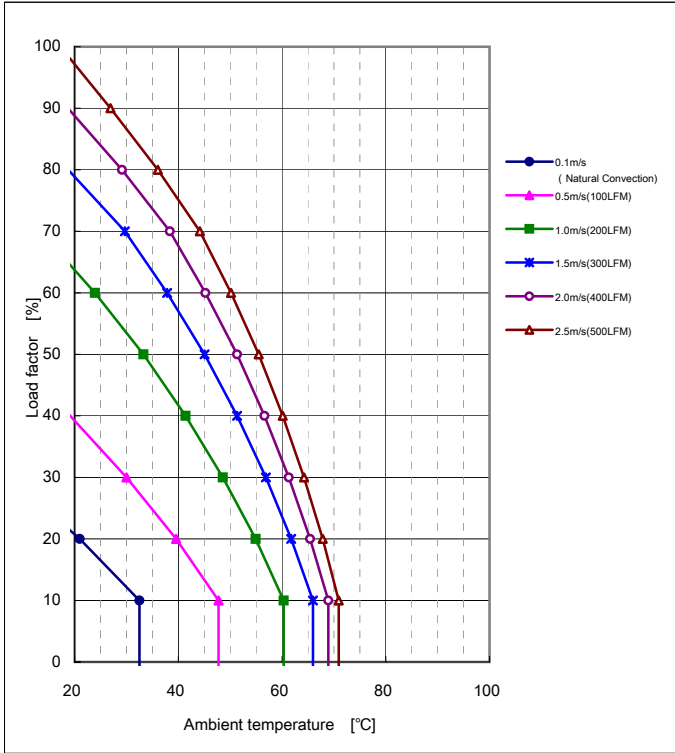
Heatsink B



Heatsink B

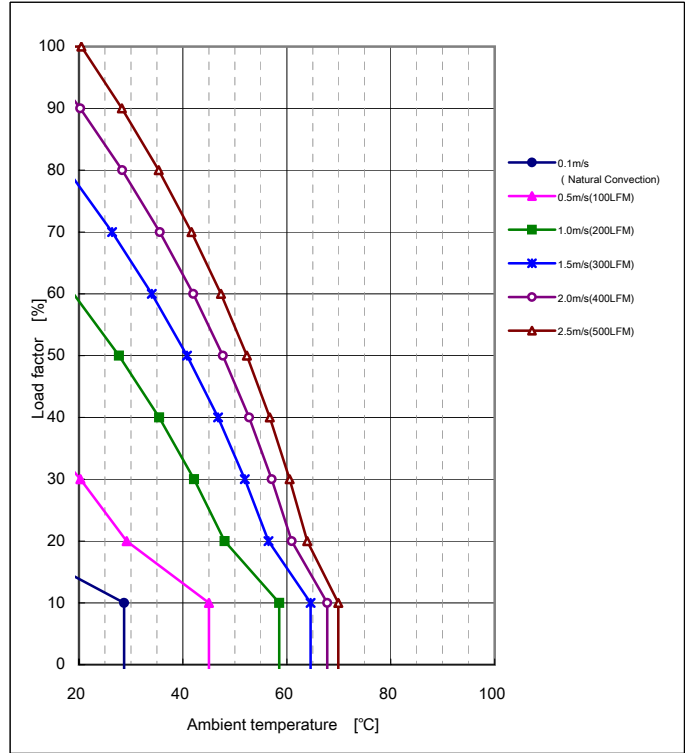
Thermal Considerations

CDS4004812

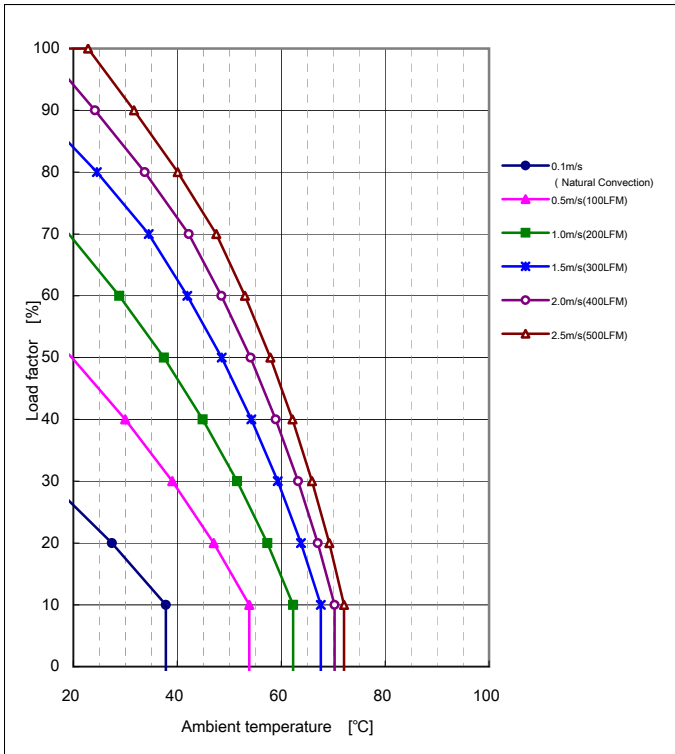


Heatsink A

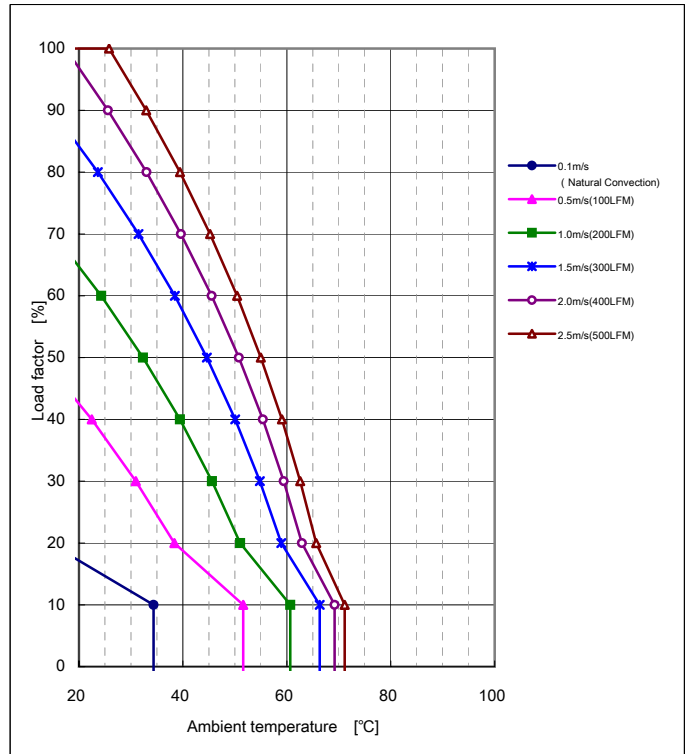
CDS4004815



Heatsink A



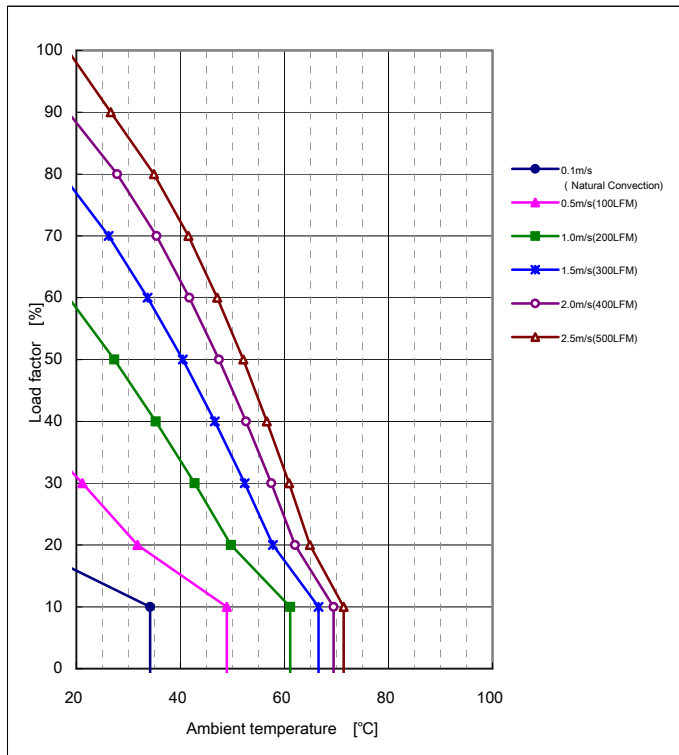
Heatsink B



Heatsink B

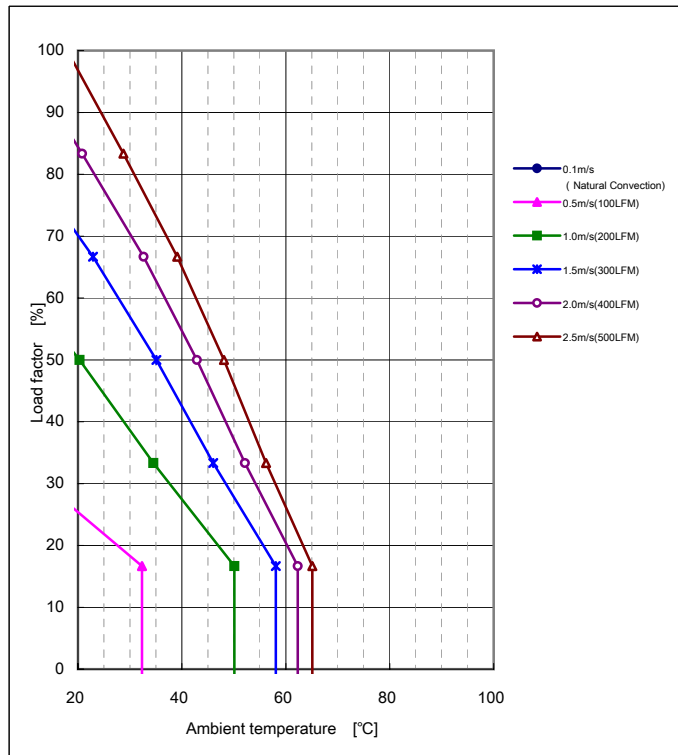
Thermal Considerations

CDS4004824

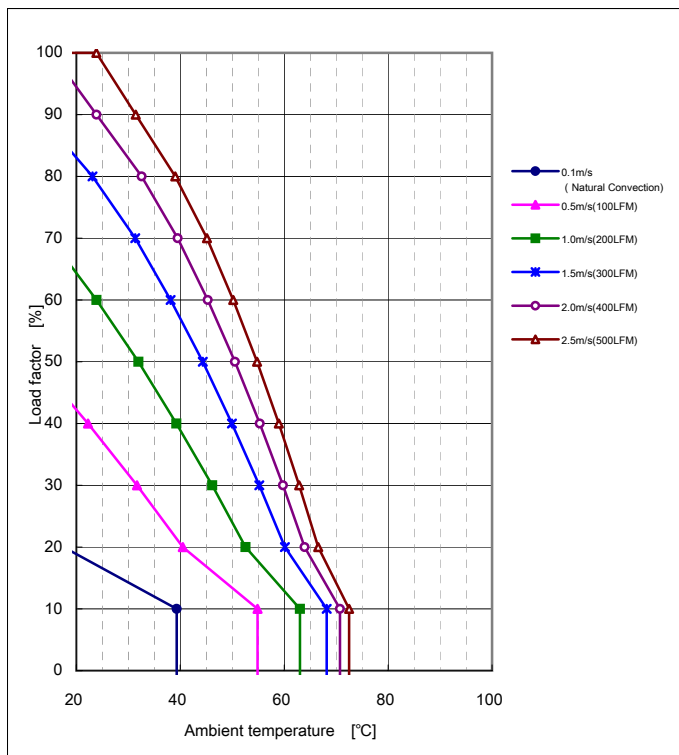


Heatsink A

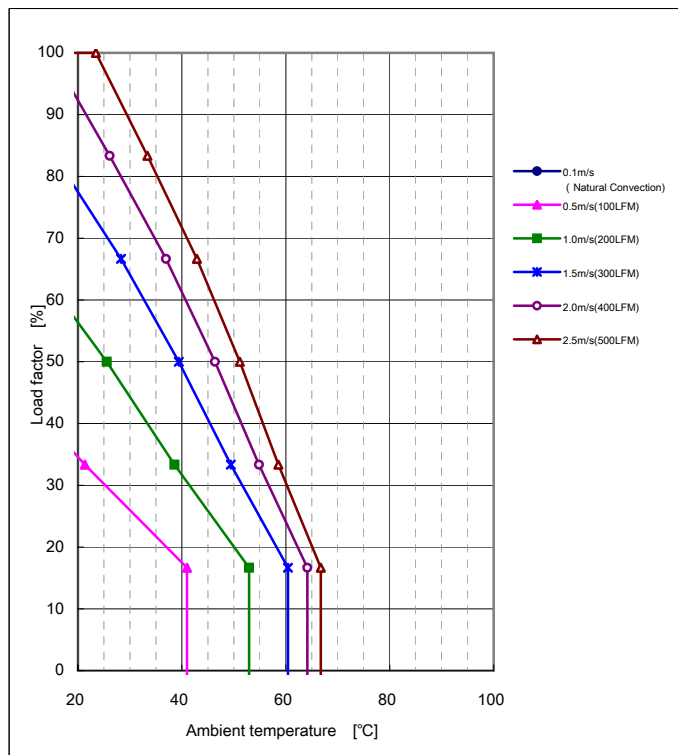
CDS4004828



Heatsink A



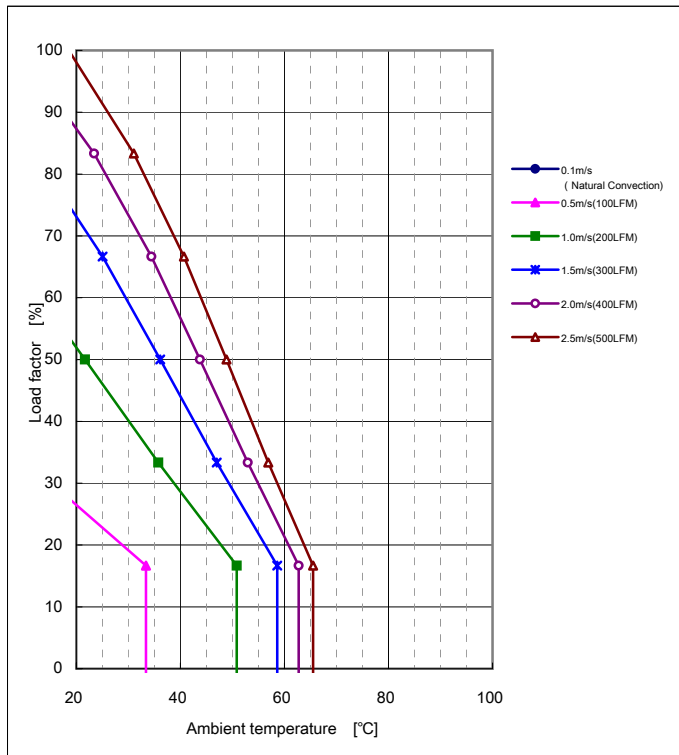
Heatsink B



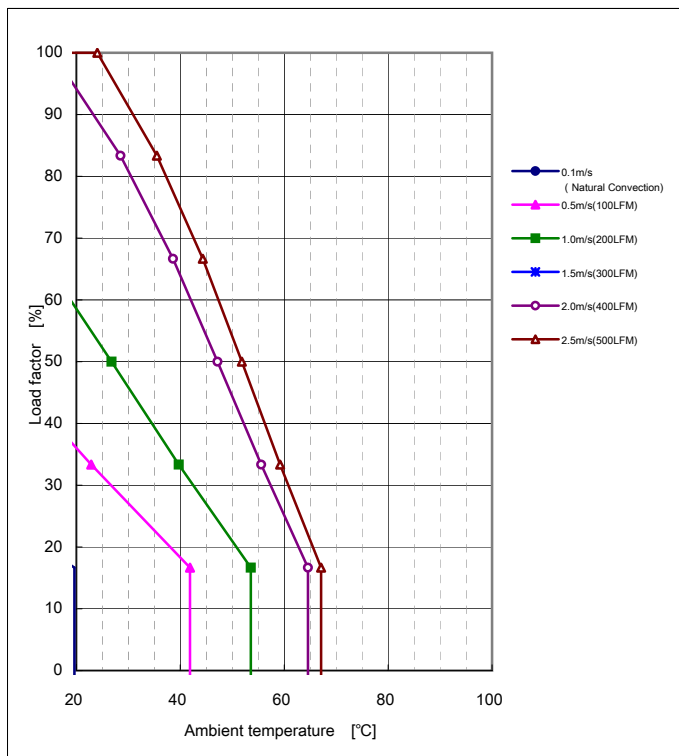
Heatsink B

Thermal Considerations

CDS5002428H



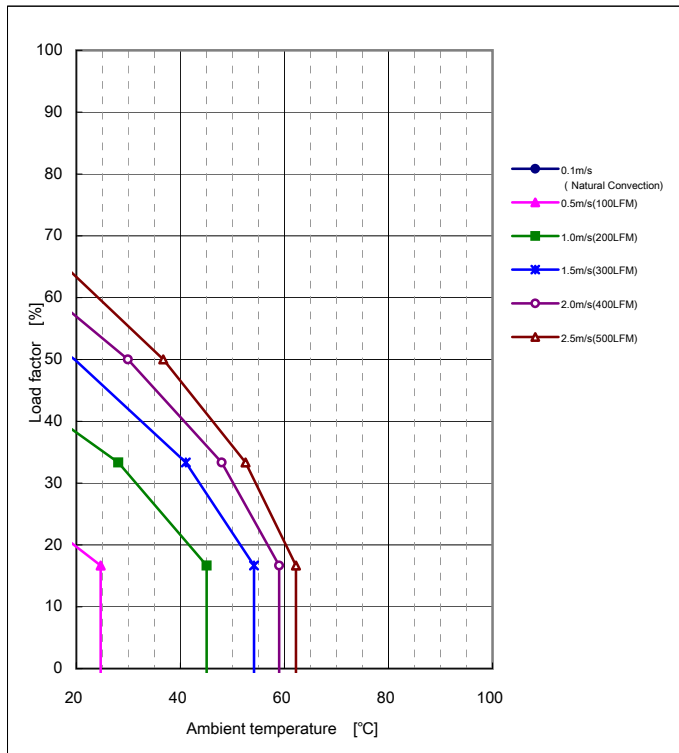
Heatsink A



Heatsink B

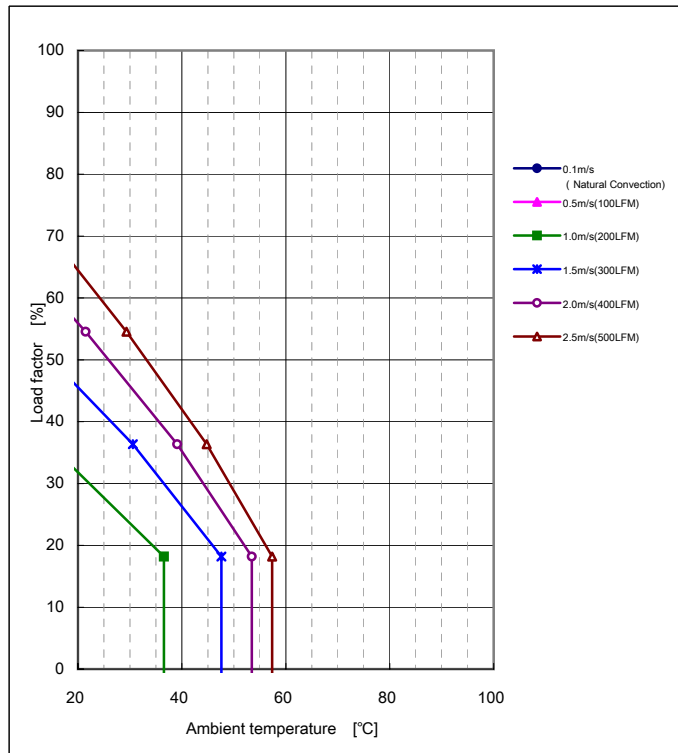
Thermal Considerations

CDS6002412

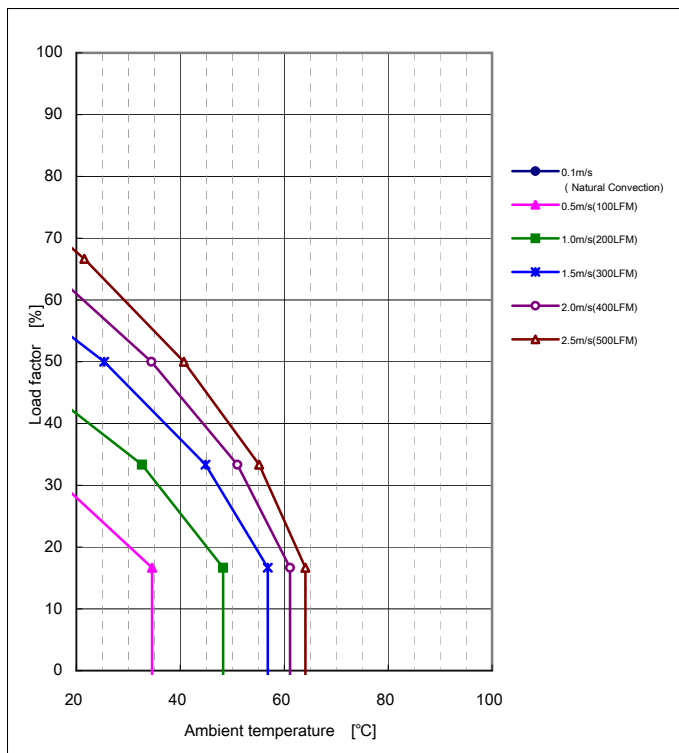


Heatsink A

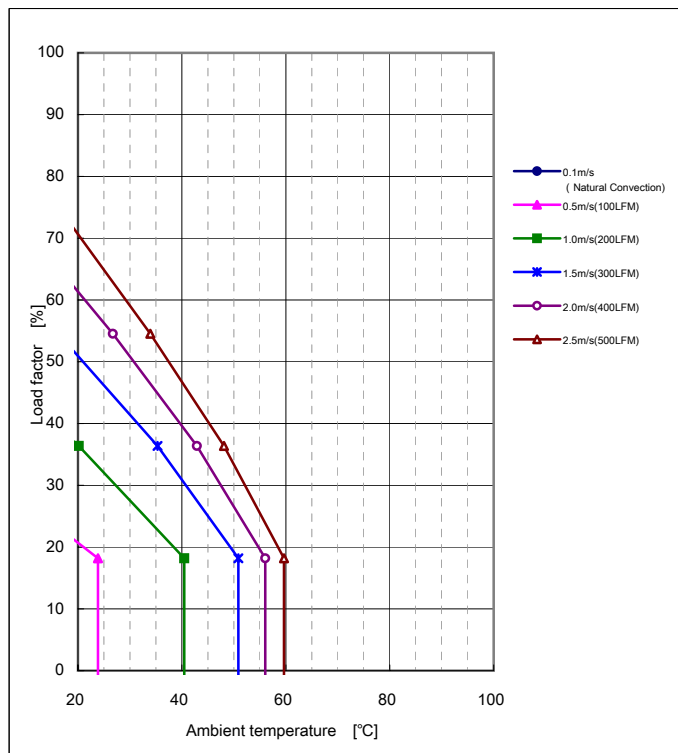
CDS6002428



Heatsink A



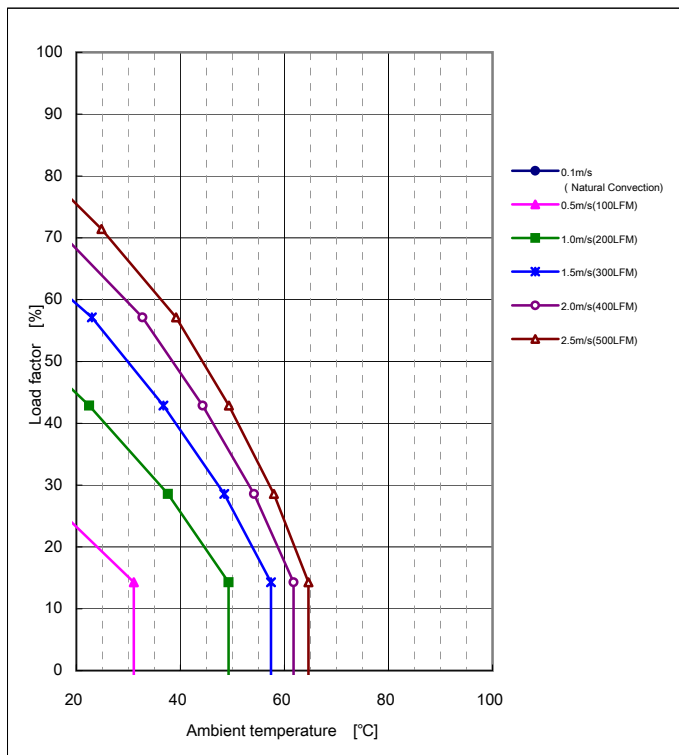
Heatsink B



Heatsink B

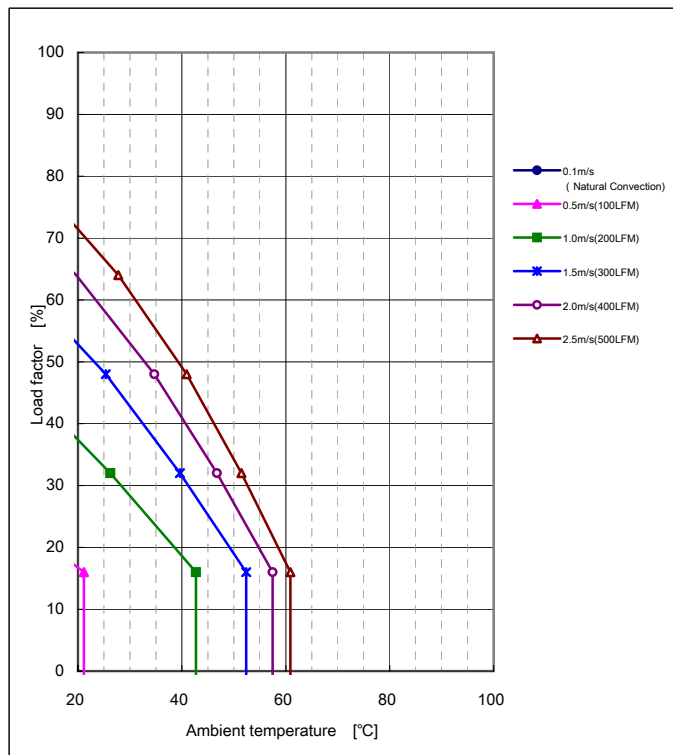
Thermal Considerations

CDS6004812

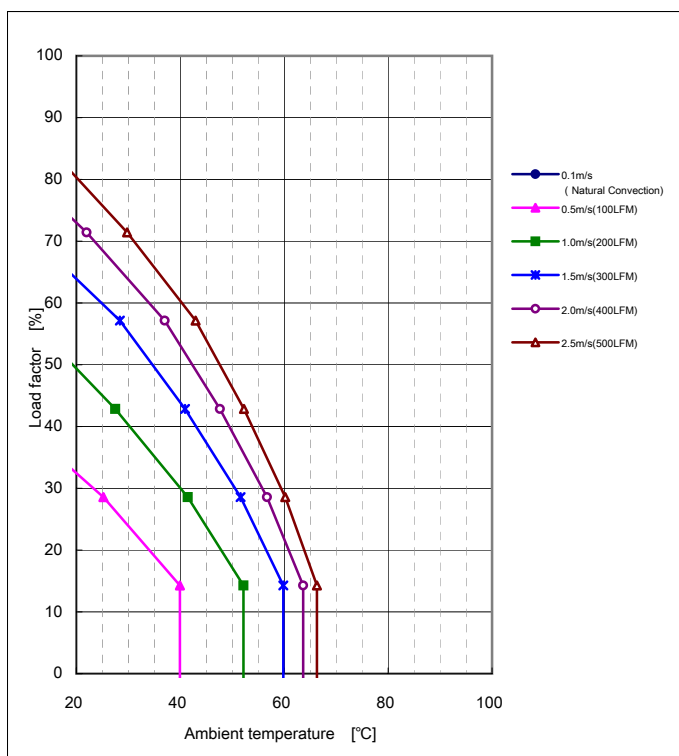


Heatsink A

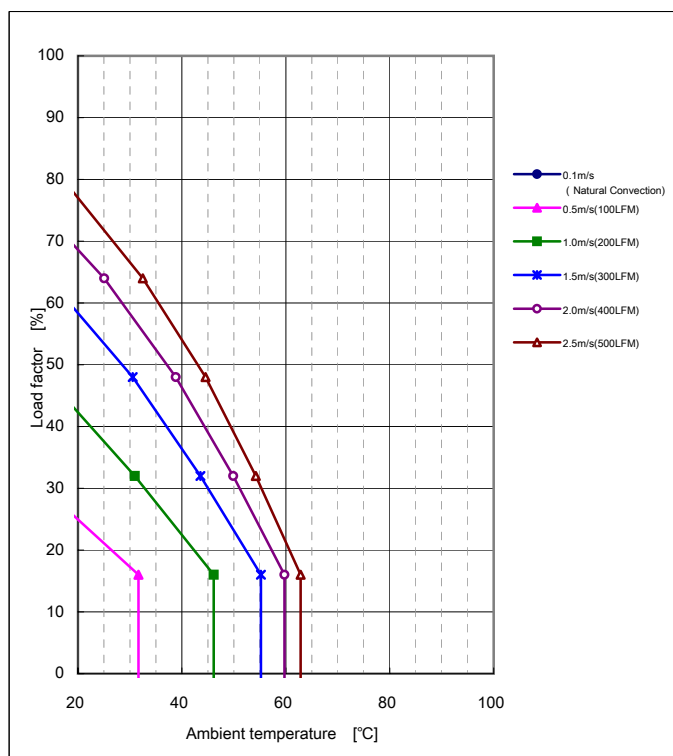
CDS6004828



Heatsink A



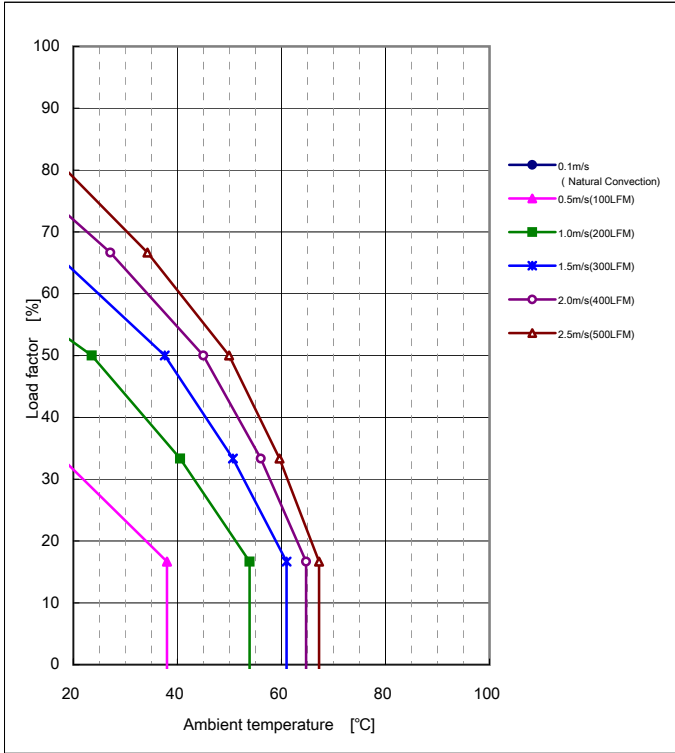
Heatsink B



Heatsink B

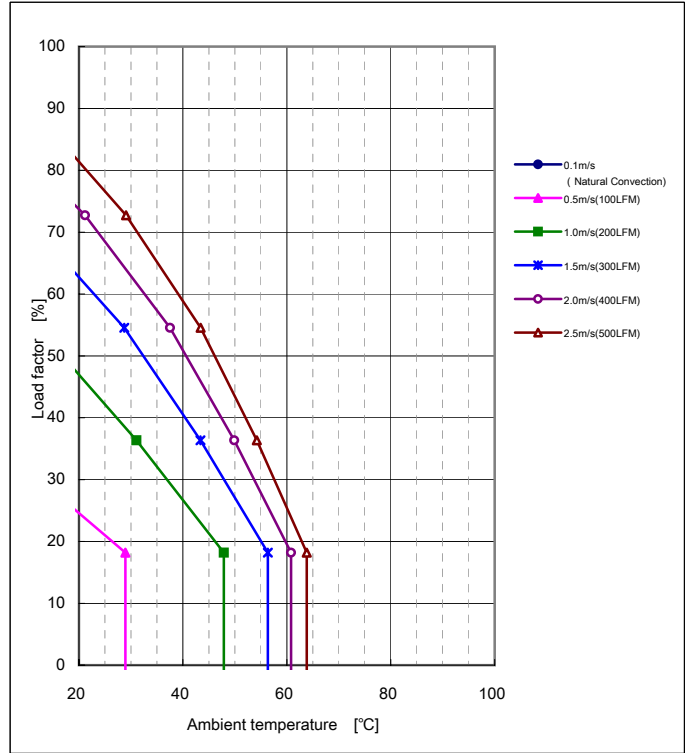
Thermal Considerations

CDS6002412H

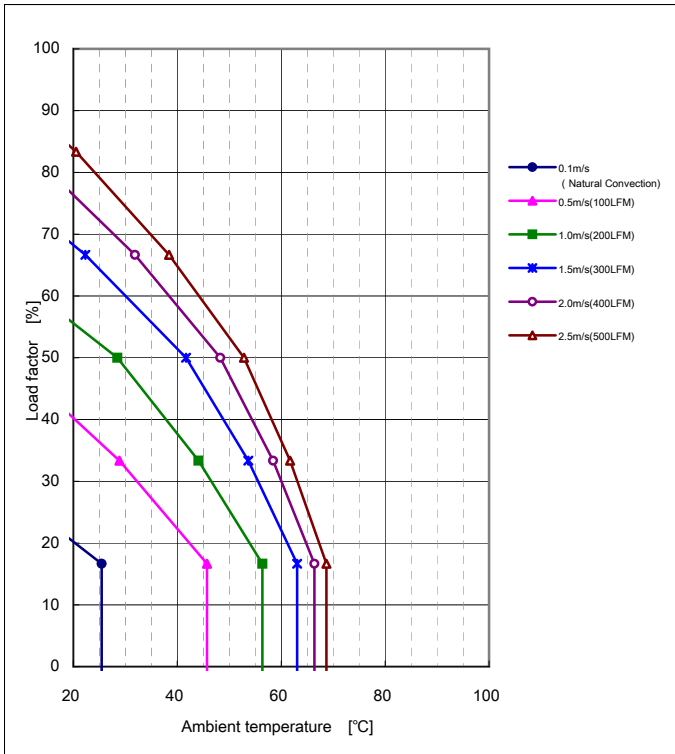


Heatsink A

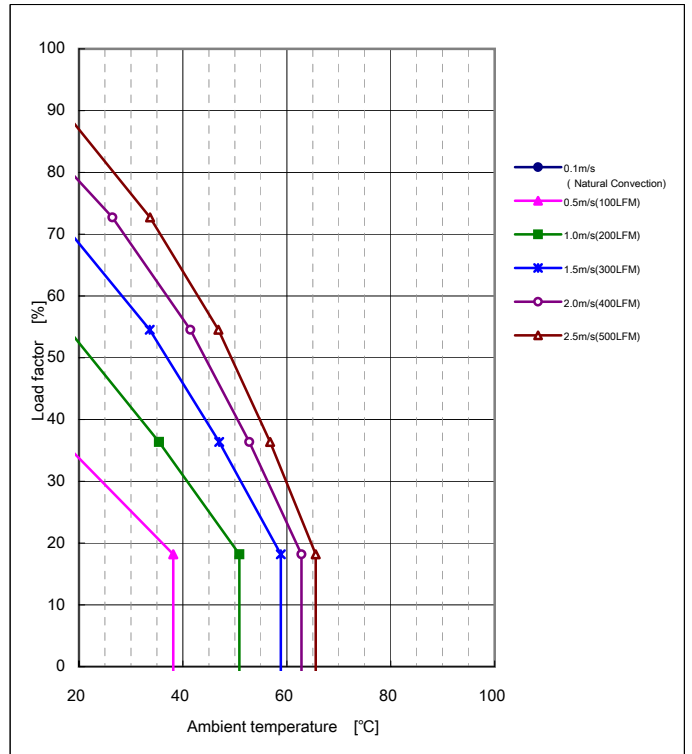
CDS6002428H



Heatsink A



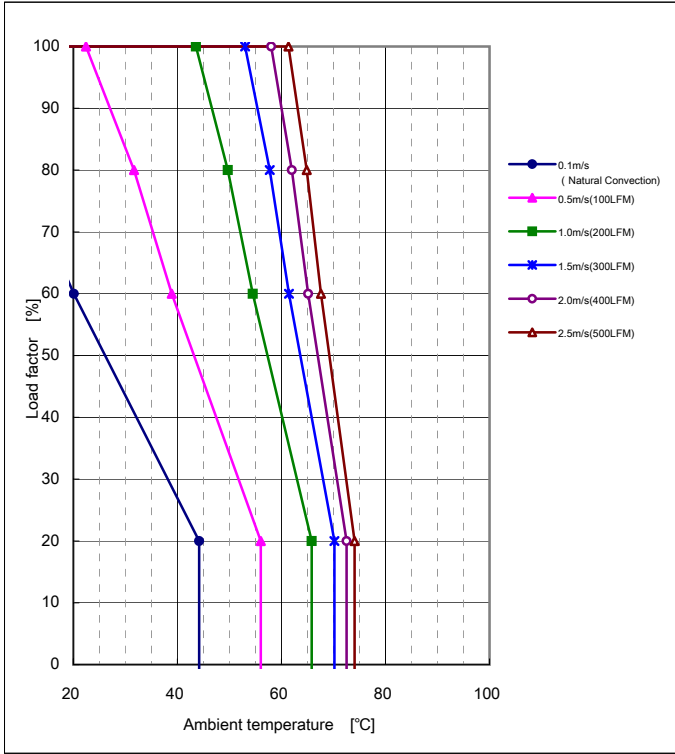
Heatsink B



Heatsink B

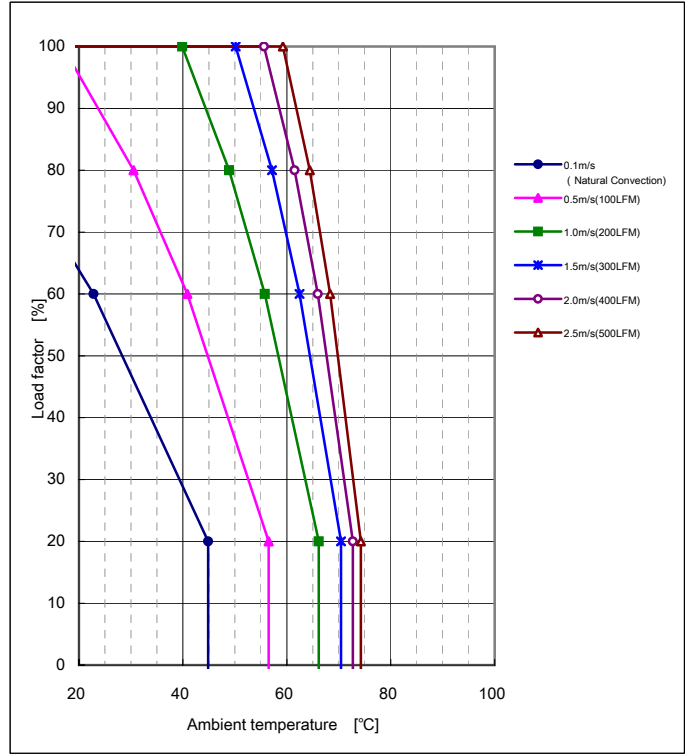
Thermal Considerations

DBS100A13R8

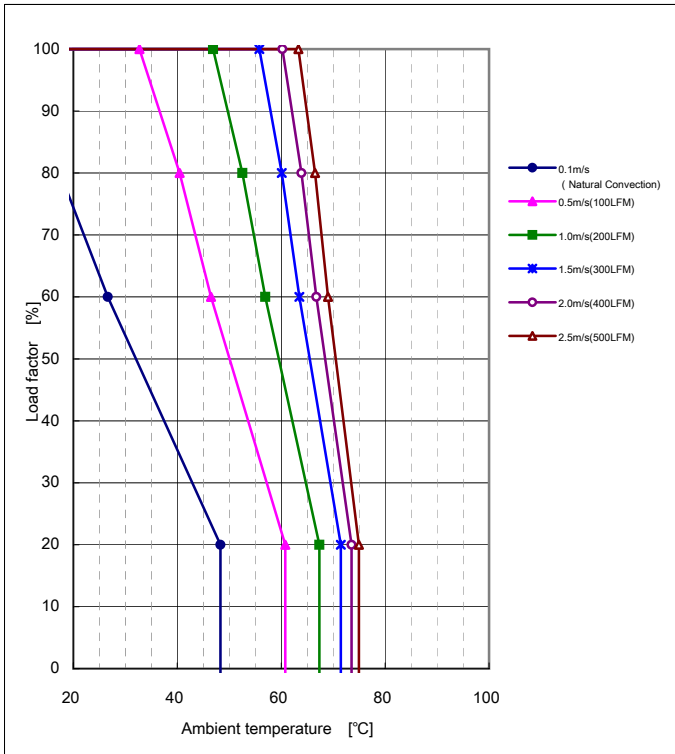


Heatsink A

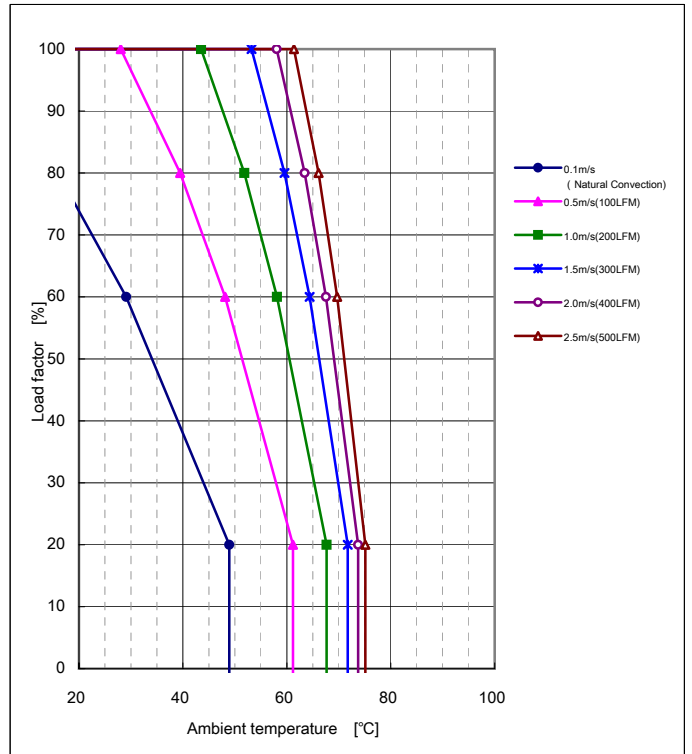
DBS150A12



Heatsink A



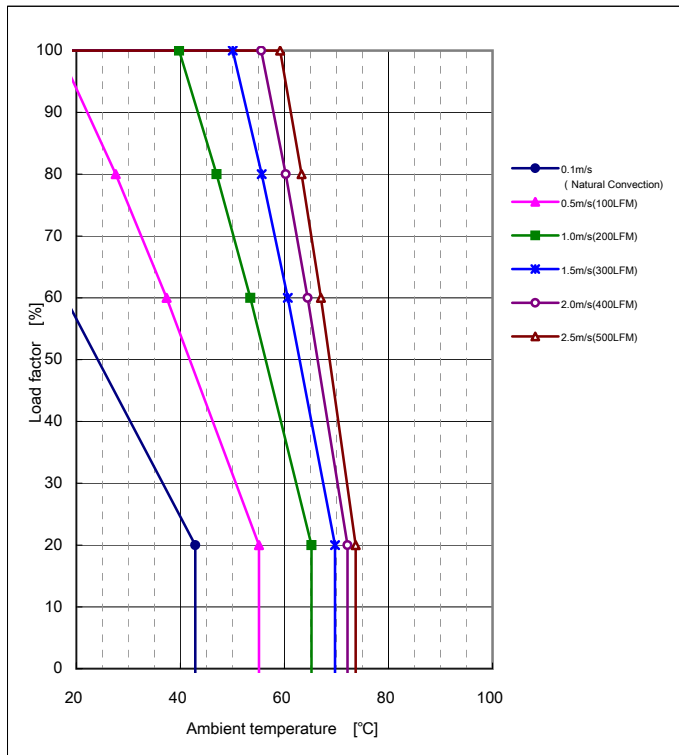
Heatsink B



Heatsink B

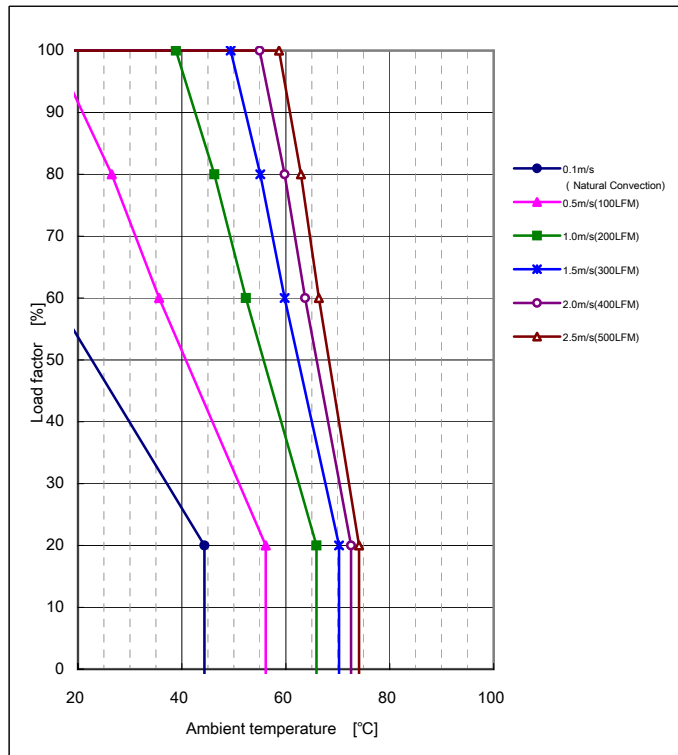
Thermal Considerations

DBS150A15

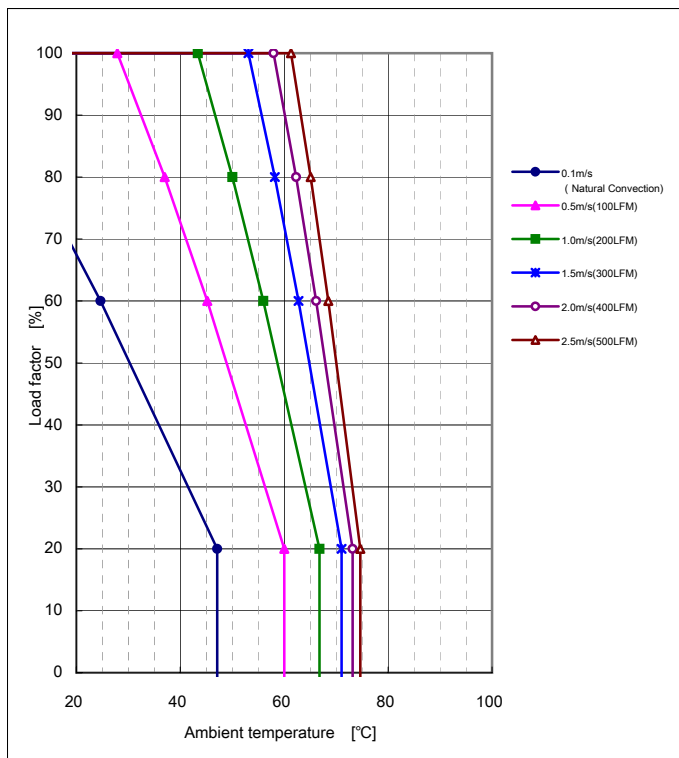


Heatsink A

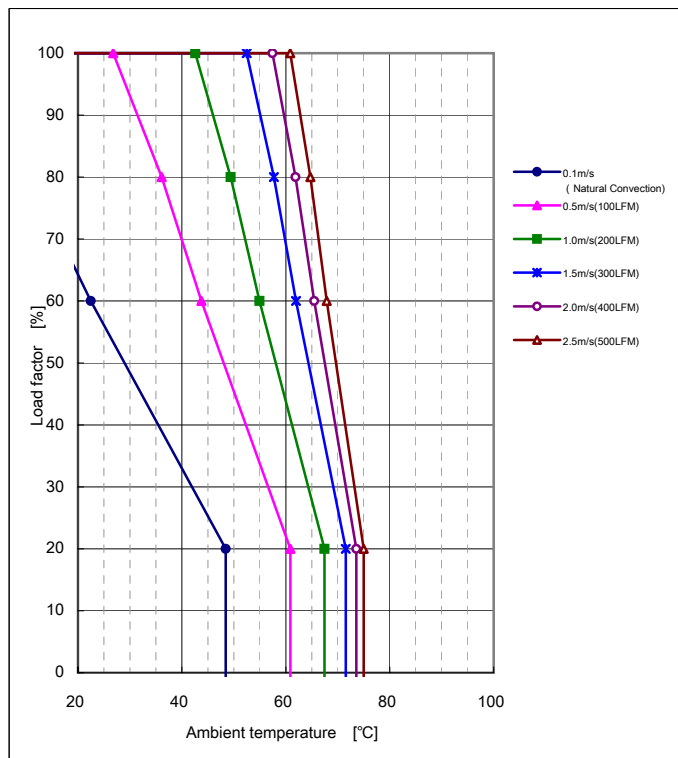
DBS150A24



Heatsink A



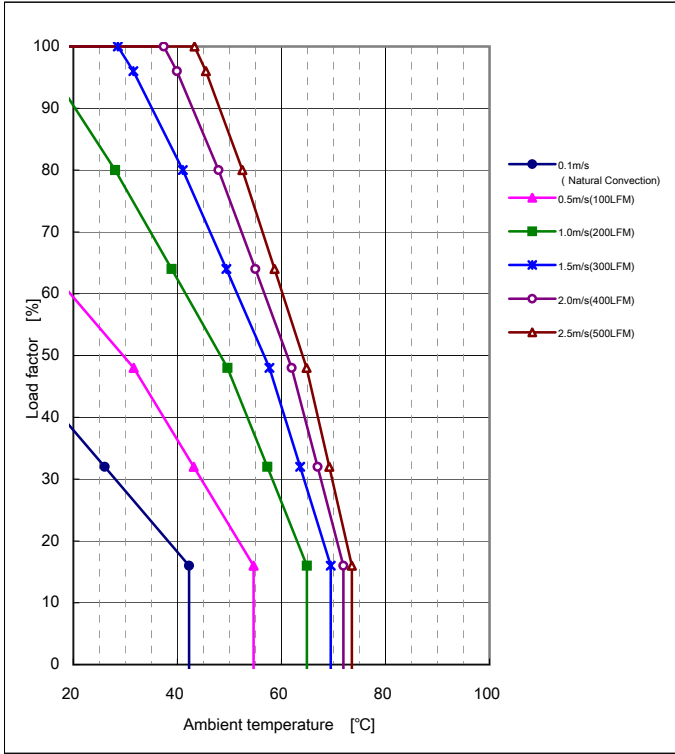
Heatsink B



Heatsink B

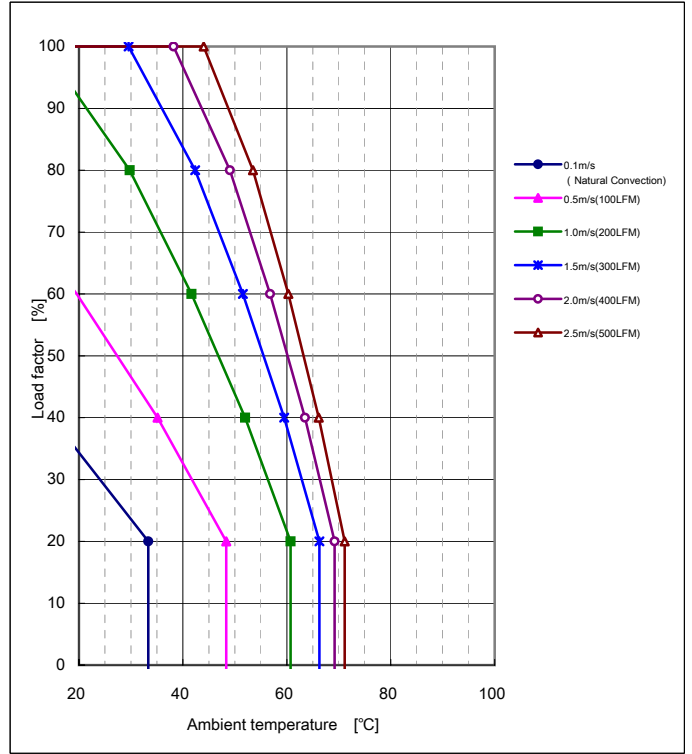
Thermal Considerations

DBS200B03

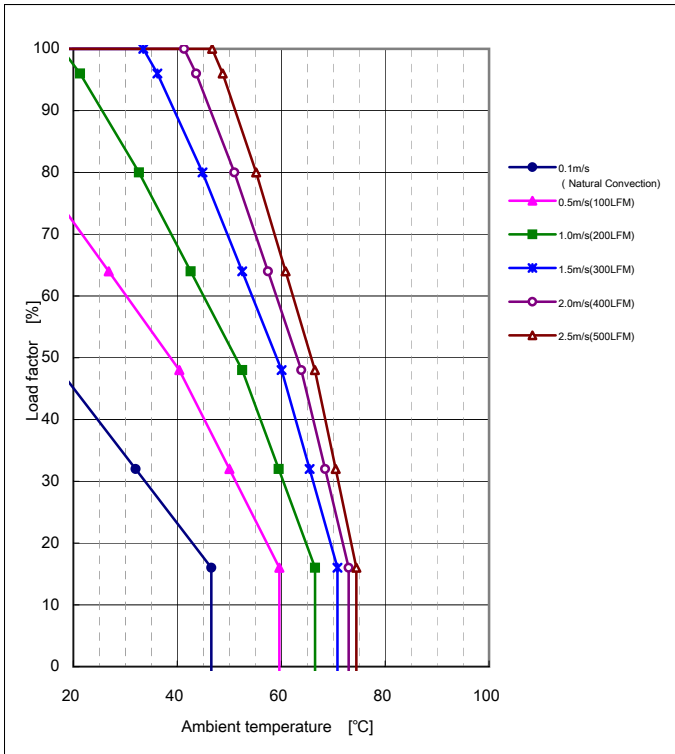


Heatsink A

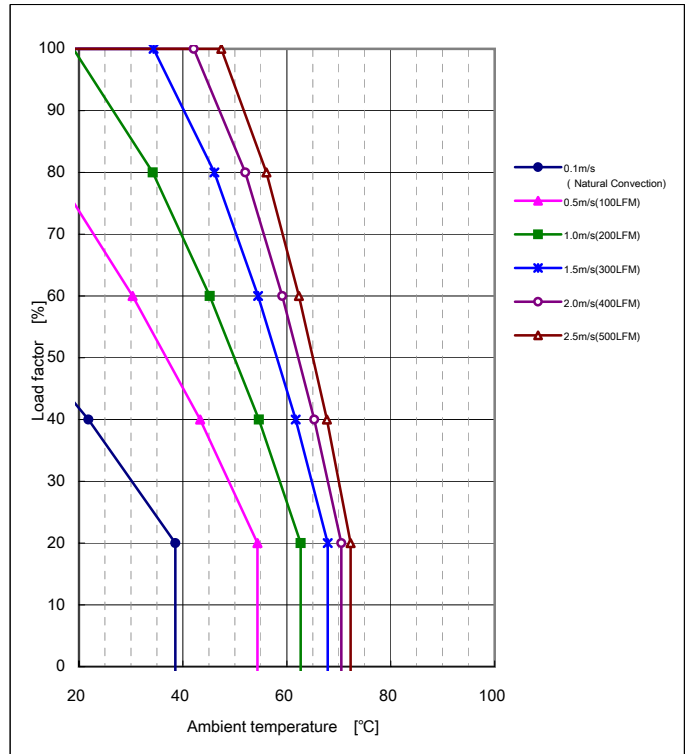
DBS200B05



Heatsink A



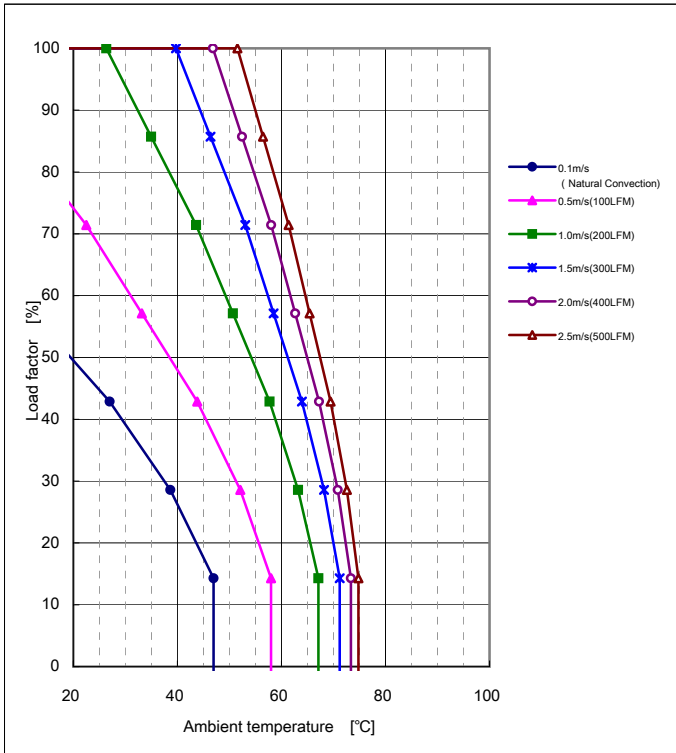
Heatsink B



Heatsink B

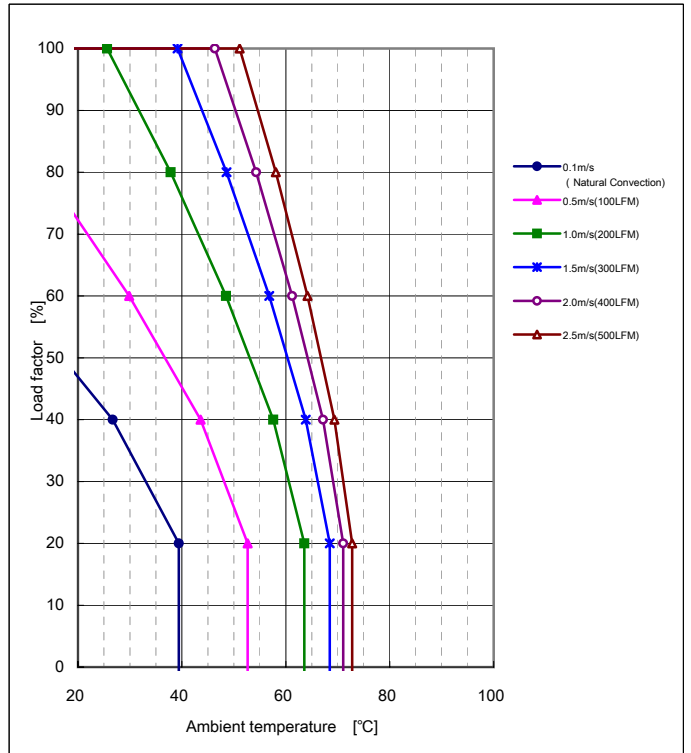
Thermal Considerations

DBS200B07

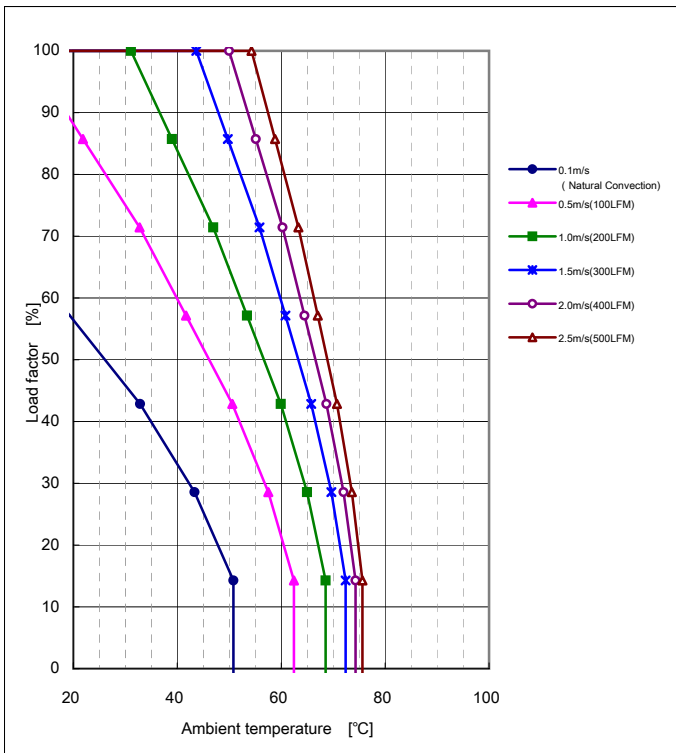


Heatsink A

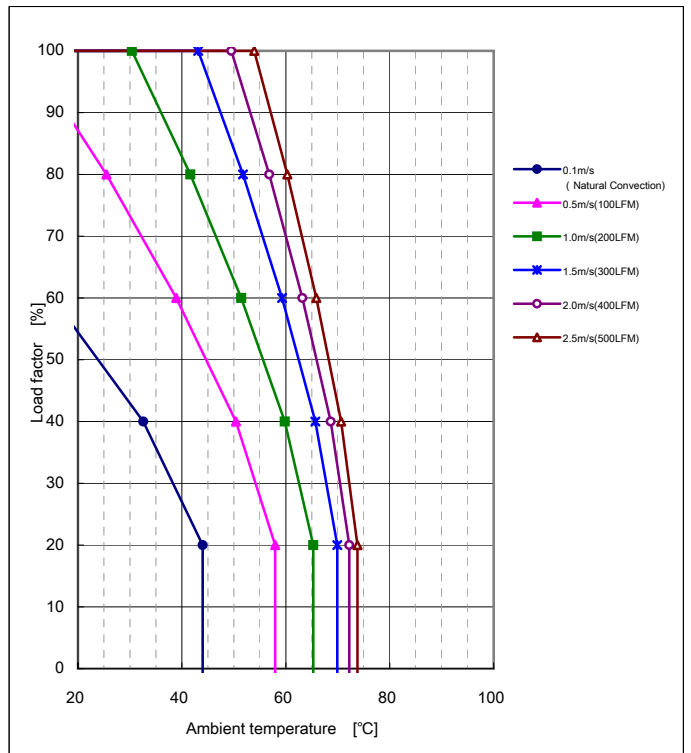
DBS200B12



Heatsink A



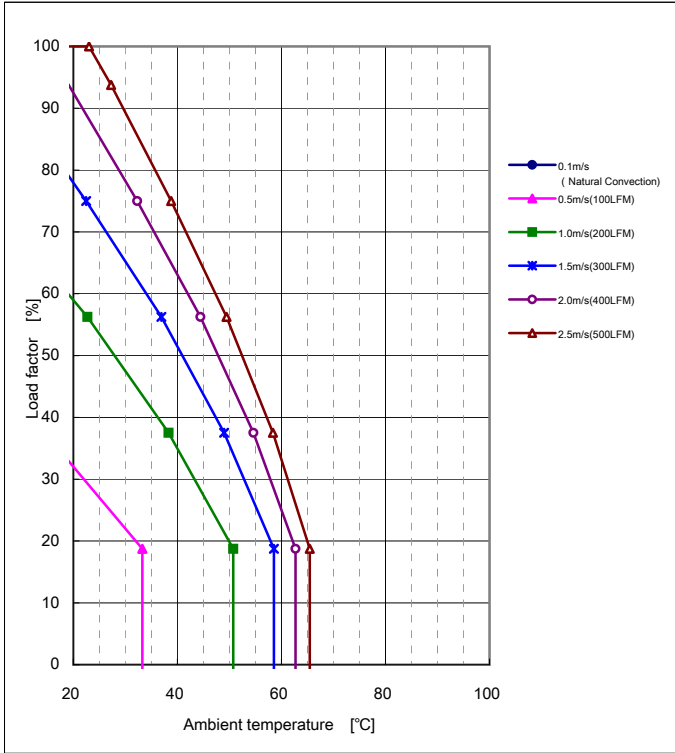
Heatsink B



Heatsink B

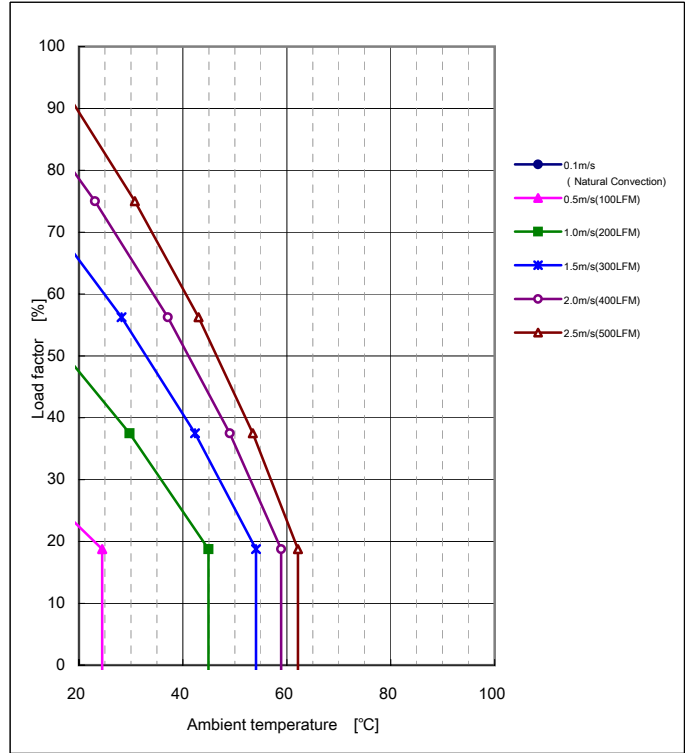
Thermal Considerations

DBS400B03

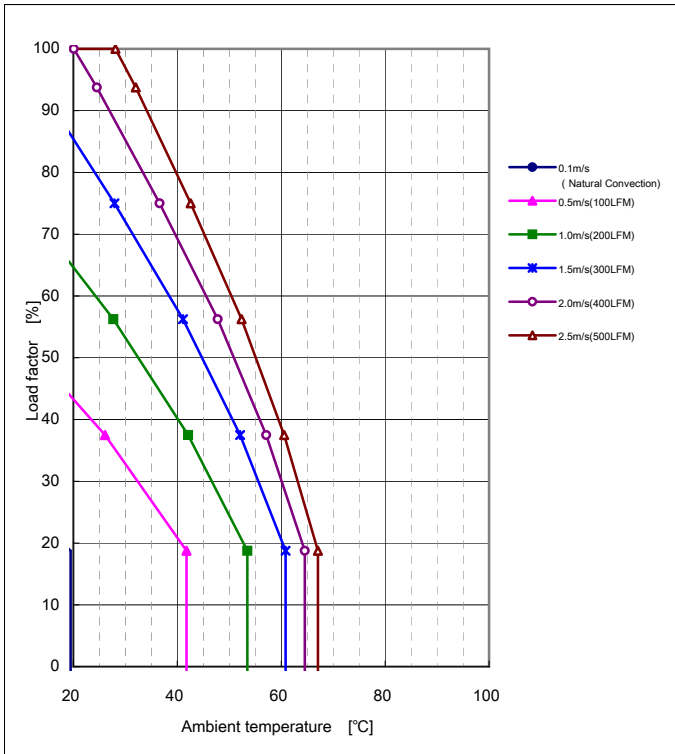


Heatsink A

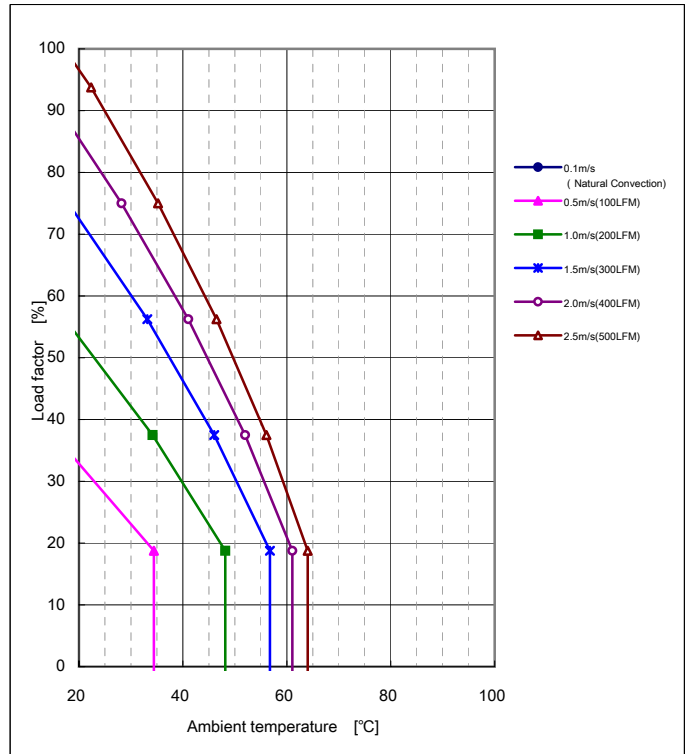
DBS400B05



Heatsink A



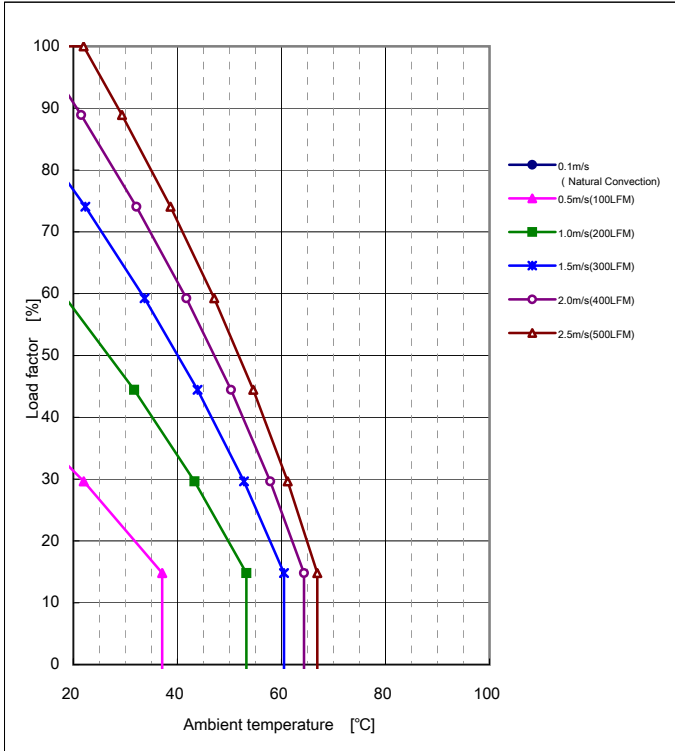
Heatsink B



Heatsink B

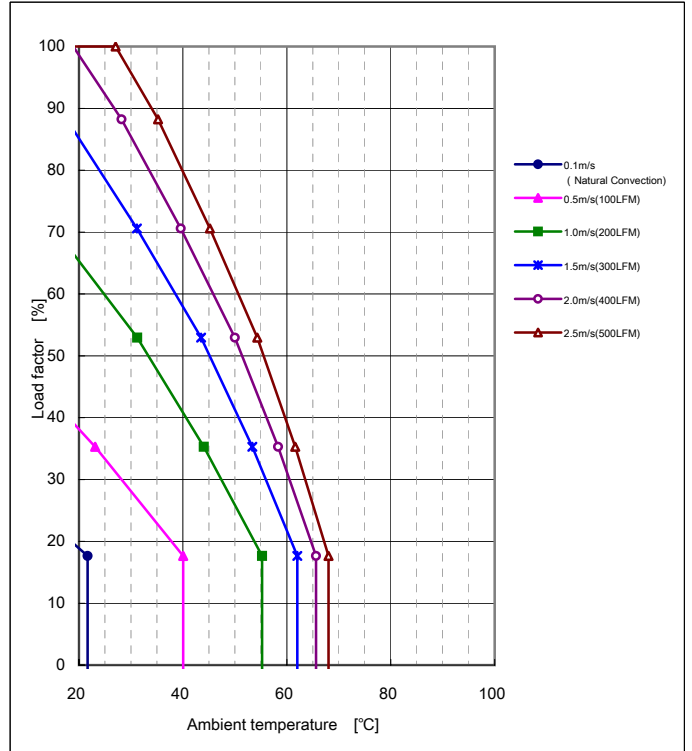
Thermal Considerations

DBS400B07

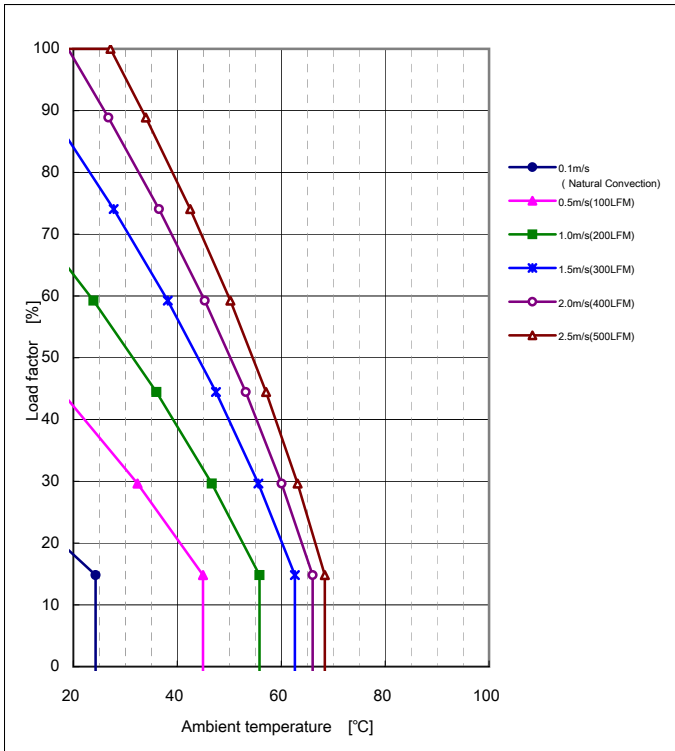


Heatsink A

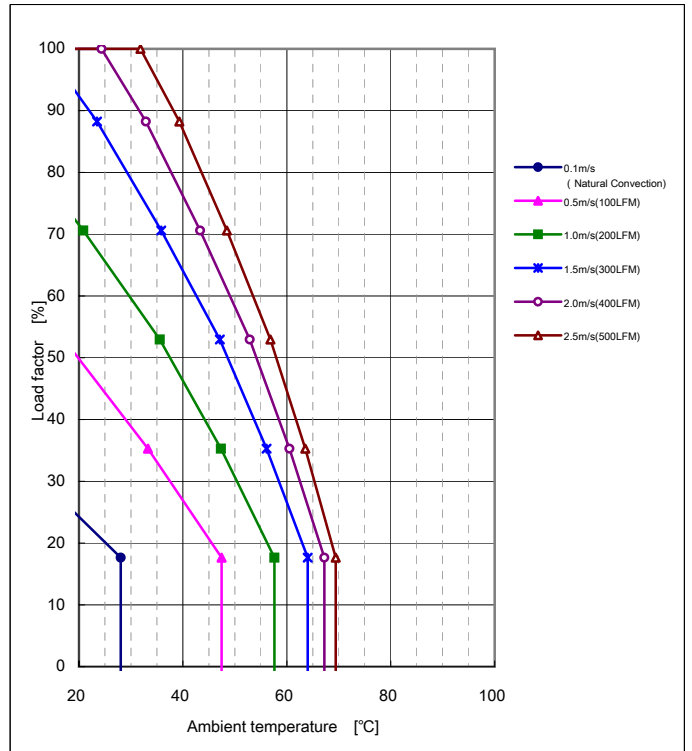
DBS400B12



Heatsink A



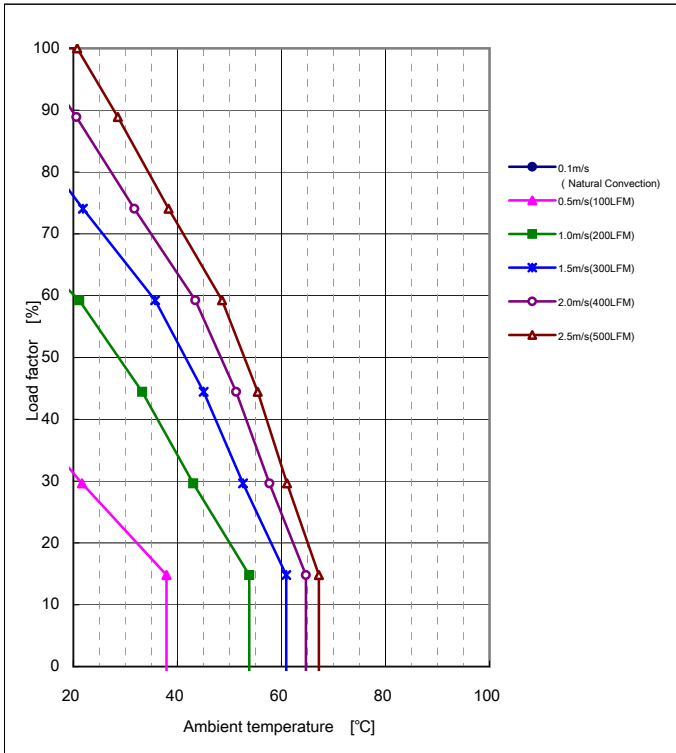
Heatsink B



Heatsink B

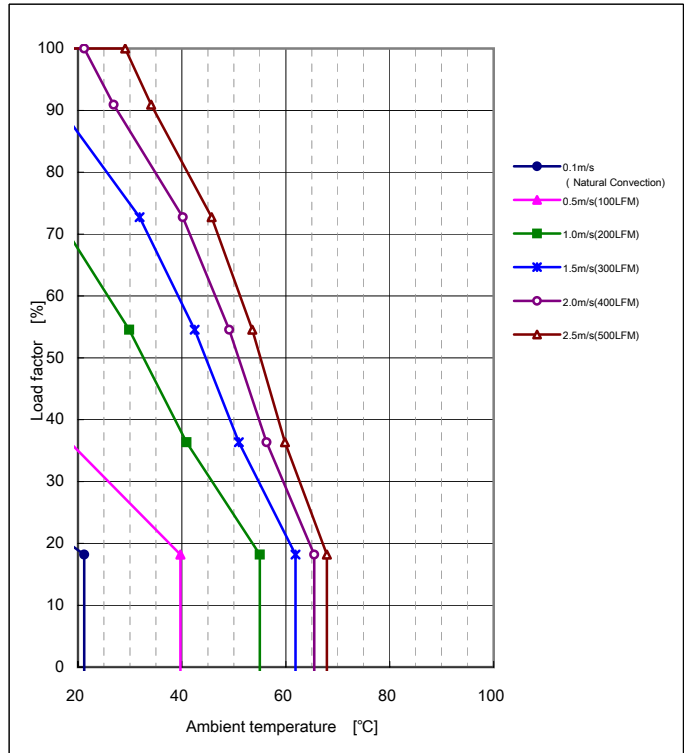
Thermal Considerations

DBS400B15

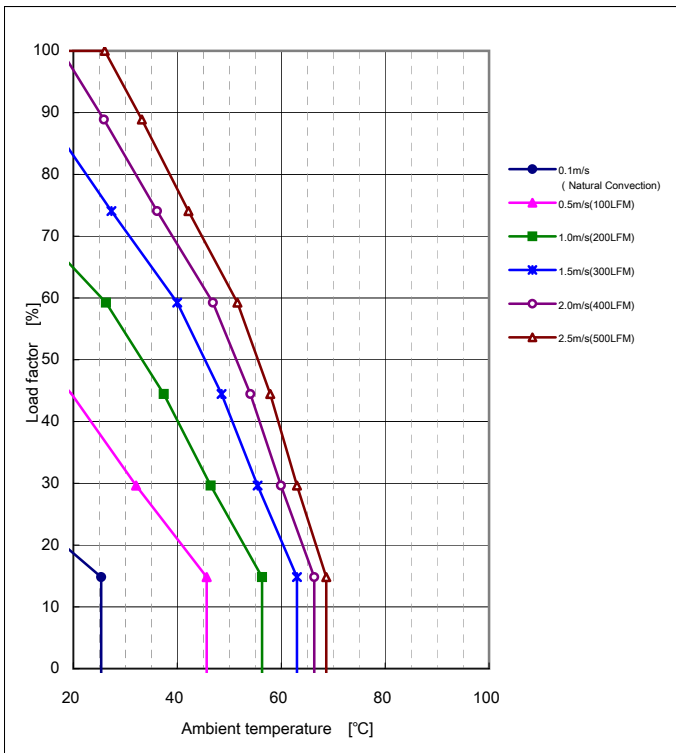


Heatsink A

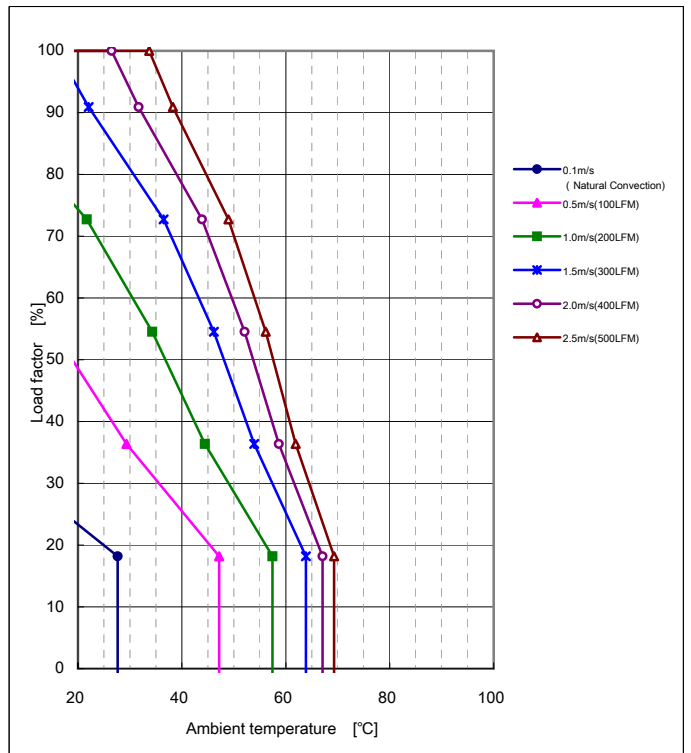
DBS400B18



Heatsink A



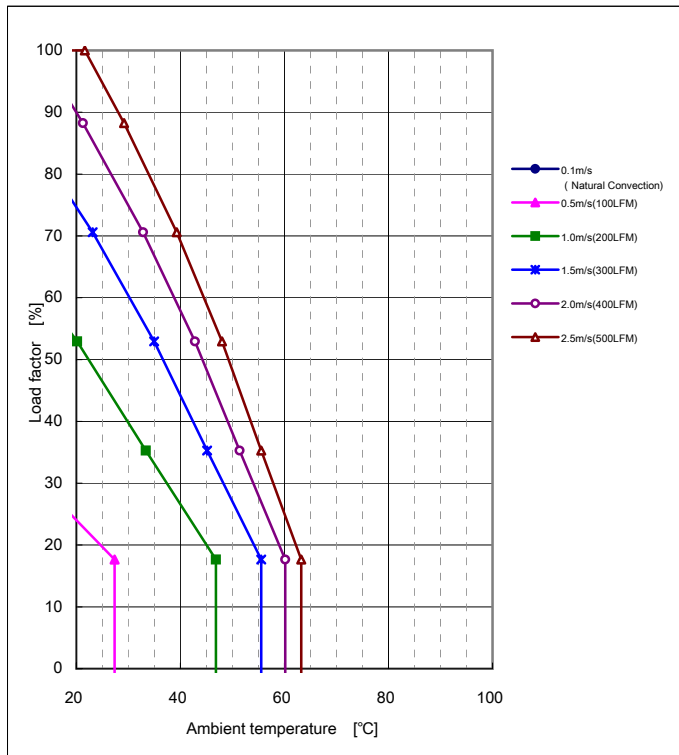
Heatsink B



Heatsink B

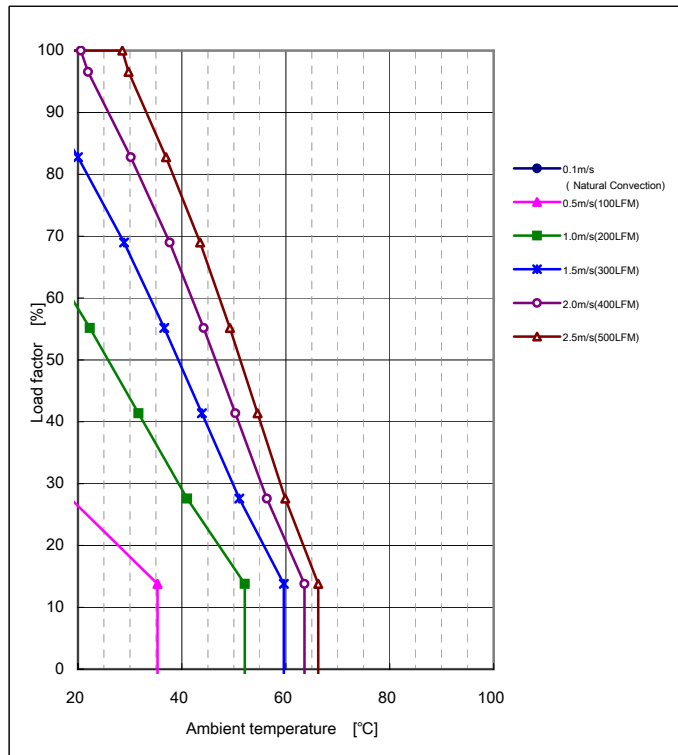
Thermal Considerations

DBS400B24

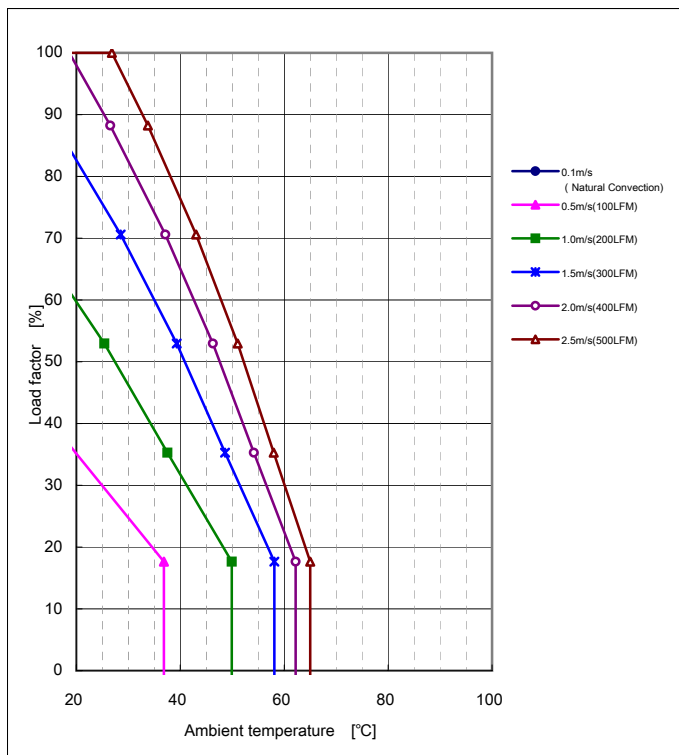


Heatsink A

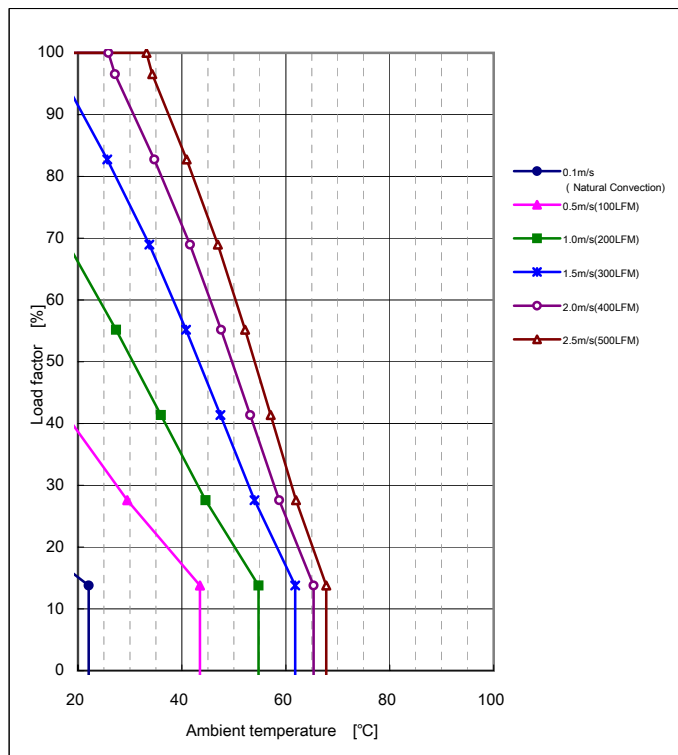
DBS400B28



Heatsink A



Heatsink B



Heatsink B