Overview and Characteristics of Fans

■Overview

A fan is a device that creates a flow of air by rotating blades by means of a motor. One of the major uses of fans is cooling control devices and other electronic equipment. Cooling fans are essential for electronic equipment, as progress in surface mount technology has enabled the development of compact devices with densely-packed components that must be protected against heat.

Today, fans must not only move air, but must also have advanced functions. Fans need advanced functions to ensure electronic equipment is cooled adequately to improve the reliability of the equipment itself. These functions include temperature sensors that can detect changes in internal temperature and adjust fan airflow, and alarms that detect faults.
Improvements such as these mark a new stage in fan technology.
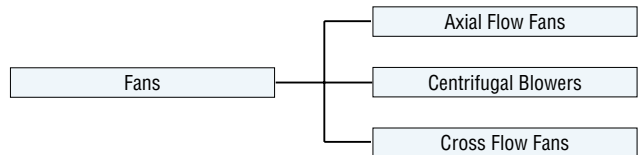
Axial Flow Fans

Centrifugal Blowers

Cross Flow Fans

■Characteristics

Fans can be classified into the following three types:

```
                 ┌── Axial Flow Fans
  Fans ──────────┼── Centrifugal Blowers
                 └── Cross Flow Fans
```

The following is a description of the characteristics of these fans.

Axial Flow Fans

Axial flow fans use a propeller to create a flow of air in the direction of the axis of rotation. Because they create a large airflow, axial flow fans are optimal for use as ventilators for overall cooling of the internal components of machinery. In the ORIX.FAN line, axial flow fans are available in a large number of sizes and voltage characteristics.
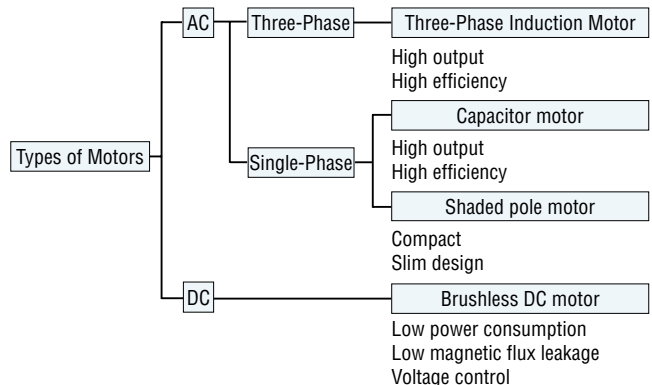
Centrifugal Blowers

Centrifugal blowers move air by means of the centrifugal force generated by rotating a cylindrical runner on which blades have been arranged.
Centrifugal blowers have a small outlet, which concentrates air in a single direction, and thus are used for local cooling. They also create large static pressure, making them optimal for cooling equipment through which air cannot flow easily and for airflow through ducts.
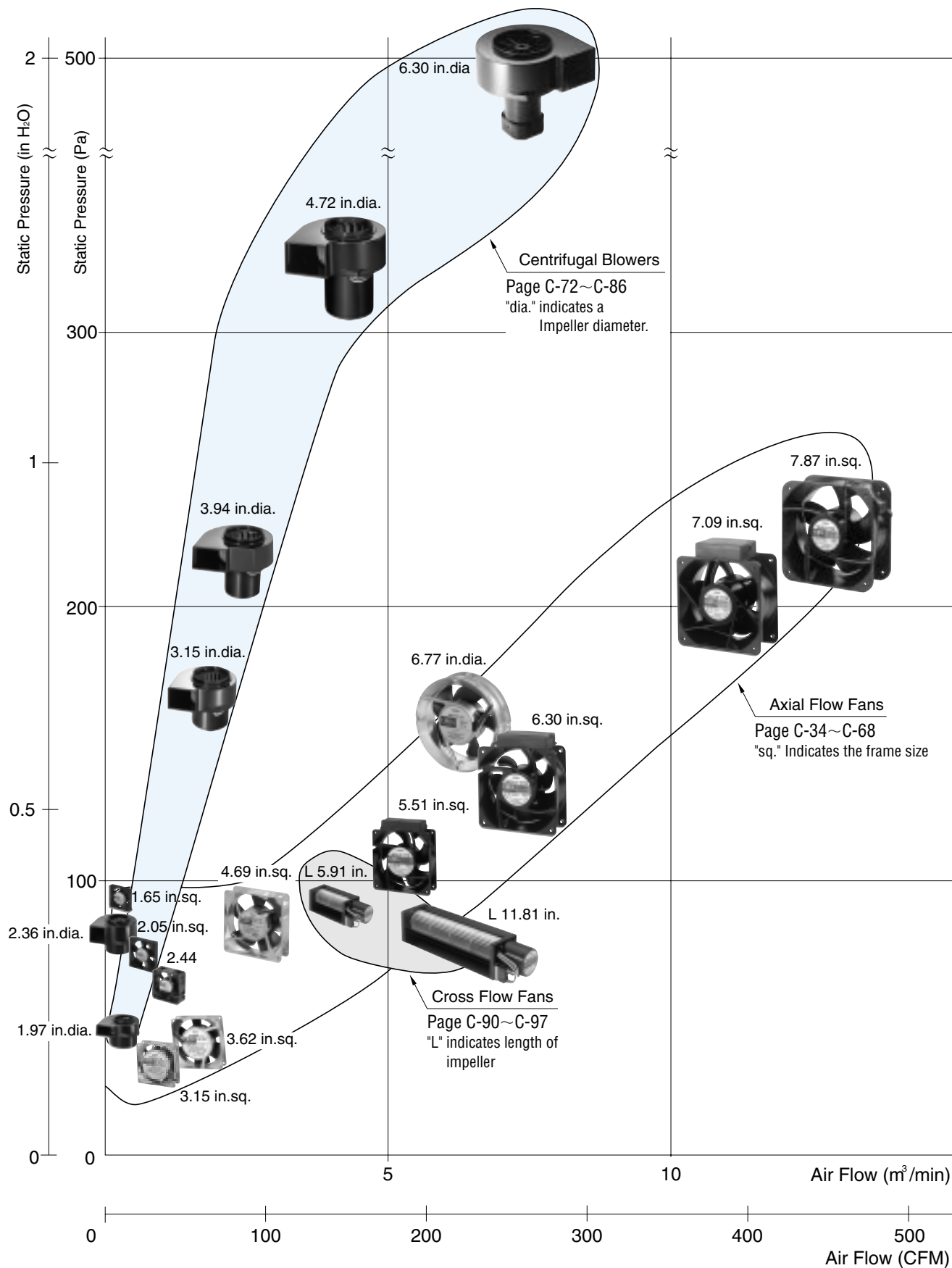
Cross Flow Fans

Cross flow fans create a wide flow of air using a long cylindrical-shaped runner. Air drawn in along the sides of the runner flows along the circumference of the runner and is blown out laterally, creating a uniform flow of air. Cross flow fans are used for cooling circuit boards installed in equipment, air curtains, and other applications.
In addition, cross flow fans offer the advantages of right-angle air flow and rectangular shape which facilitates installation in corners and saves space.

Each of these types of fans is available with AC or DC input. Depending on the type of motor used, fans can also offer the following characteristics:

```
                    ┌── AC ──┬── Three-Phase ──── Three-Phase Induction Motor
                    │        │                    High output
                    │        │                    High efficiency
                    │        │                 ┌─ Capacitor motor
  Types of Motors ──┤        └── Single-Phase ─┤  High output
                    │                          │  High efficiency
                    │                          └─ Shaded pole motor
                    │                             Compact
                    │                             Slim design
                    └── DC ───────────────────── Brushless DC motor
                                                  Low power consumption
                                                  Low magnetic flux leakage
                                                  Voltage control
```

A comparison of the performance characteristics of the various types of fans is given in the graphs below.
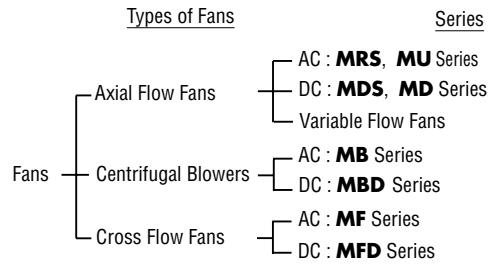The symbols indicate the intersection of maximum air flow and maximum static pressure of standard speed fans.

Note: The diagram has been prepared to facilitate the comparison of fan characteristics. In actuality, static pressure is 0 at maximum airflow, and airflow is 0 at maximum static pressure.

Static Pressure (in H₂O)
Static Pressure (Pa)

6.30 in.dia

4.72 in.dia.

Centrifugal Blowers
Page C-72~C-86
"dia." indicates a
Impeller diameter.

3.94 in.dia.

3.15 in.dia.

6.77 in.dia.

6.30 in.sq.

5.51 in.sq.

7.87 in.sq.

7.09 in.sq.

Axial Flow Fans
Page C-34~C-68
"sq." Indicates the frame size

4.69 in.sq.

L 5.91 in.

L 11.81 in.

1.65 in.sq.

2.05 in.sq.

2.36 in.dia.

2.44

1.97 in.dia.

3.62 in.sq.

3.15 in.sq.

Cross Flow Fans
Page C-90~C-97
"L" indicates length of impeller

Air Flow (m³/min)

Air Flow (CFM)

Types of Fans

- **High air flow axial flow fans**
- **High static pressure centrifugal blowers**
- **Wide air flow cross flow fans**
- **Variable flow fans features control of fan characteristics.**

The ORIX.FAN line ranges from compact DC fans to large fans with high air flow. It also includes Variable flow fans whose characteristics can be adjusted according to conditions. This wide product range offers diverse functions in models of various sizes.

Types of Fans		Series
	Axial Flow Fans	AC : **MRS**, **MU** Series
		DC : **MDS**, **MD** Series
		Variable Flow Fans
Fans	Centrifugal Blowers	AC : **MB** Series
		DC : **MBD** Series
	Cross Flow Fans	AC : **MF** Series
		DC : **MFD** Series

AC Axial Flow Fans

MRS Series C-34

These high-efficiency, large air flow axial flow fans are available in mounting bases ranging from 5.51 inch to 7.87 inch and also meet UL, CSA, EN/IEC standards and CE Marking (LVD). These lines include models with built-in alarm circuits that can detect fan rotation faults and respond by outputting alarm signals.

Frame size: 7.87 in.sq., 7.09 in.sq., 6.30 in.sq., 5.51 in.sq.
Voltage: Single-Phase 100V/115V, 200V/230V, Three-Phase 200V/230V

MU Series C-42

The **MU** series is a basic line of compact AC axial flow fans. These fans are equipped with excellent safety features, meeting UL, CSA, EN/IEC standards, Electrical appliance and material control law and CE Marking(LVD).

Frame size: 4.69 in.sq., 3.62 in.sq., 3.15 in.sq.
Voltage: Single-Phase 115V, 220V/230V

DC Axial Flow Fans

MDS•MDS Series C-50

These compact axial flow fans use high-performance brushless DC motors. They are optimal for cooling DC equipment.
A built-in alarm type is also available which detects and signals fan rotation abnormalities or stoppages.
These fans are meeting UL, CSA, EN/IEC standards and CE Marking (EMC).

Frame size: 6.77 in.dia., 4.69 in.sq., 3.62 in.sq., 3.15 in.sq., 2.44 in.sq., 2.05 in.sq., 1.65 in.sq.
Voltage: 5V, 12V, 24V DC

Variable Flow Fans

VARIOFLOW C-66

The internal power control device allows adjustment of air flow to match requirements.

AC Axial Flow Fans
7.09 in.sq.
MRS18V2-□
UL, CSA, EN/IEC standards and CE Marking (LVD)   Voltage: Single-Phase 100/115V, 200/230V

Centrifugal Blowers

MB Series (for AC) C-74
MBD Series (for DC) C-84

By maximizing static pressure, these centrifugal blowers can deliver air exactly where needed, making them optimal for localized cooling and for airflow through ducts. They also can be used either from a fixed position or mounted on moving parts. The **MB** series are meeting UL, CSA, EN/IEC standards and CE Marking(LVD).

Impeller Diameter: 6.30 in.dia., 4.72 in.dia., 3.94 in.dia., 3.15 in.dia., 2.36 in.dia., 1.97 in.dia.
Voltage: Single-Phase 100/115V, 200/220/230V, Three-Phase 200/230V
24V DC

Cross Flow Fans

MF Series (for AC) C-90
MFD Series (for DC) C-94

These cross flow fans deliver a wide, uniform flow of air by means of 11.81 inch or 5.91 inch impellers. Cross flow fans offer the advantages of right-angle air flow and compact rectangular shape, facilitating installation in corners and savings space.
The **MF** series are meeting UL, CSA, EN/IEC standards and CE Marking(LVD).
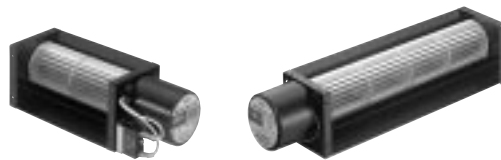
MF Series   **MFD Series**

Length of impeller: 11.81 in.,5.91 in.
Voltage: Single-Phase 100/115V, 200/220/230V
24V DC

Selecting a Fan

There are a lot of ways to select a fan. For example, some equipment has limited mounting space for a fan, and other needs a fan with supplementary functions. Also, selecting a fan according to its use is one of the knacks in order to bring out the best in its performance and use it effectively.
We would like you to select the best fan you need in accordance with the following selecting procedure.

■Selecting Procedure of a Fan

| 1. Select a Fan for Its Size | Page C-7 |

The case your equipment size has been already settled, and its mounting space for a fan is limited.

Fan Size : frame size, frame thickness, diameter of runner, etc.

| 2. Select a Fan for Its Power Source Specification | Page C-8 |

The case you would like to use a fan which has the same power source specification as your equipment does, or like to apply its built-in power source to a fan.

The case you need a fan which has the same power source specification as your exporting partner uses.

| 3. Select a Fan for Its Supplementary Functions | Page C-9 |

The case you need to adjust air-flow to your equipment and static pressure, or input only required air-flow to decrease noise.

The case you need measures against any abnormality of your equipment when the fan has a trouble with its rotation.

| 4. Select a Fan for Its Use | Page C-10 |

An appropriate fan differs depending on its use. Please look at a fan for its use in order to bring out the best in its performance and use it most effectively.

| 5. Example of fan selection | Page C-12 |

Computations can be carried out to obtain the most appropriate fan according to the conditions of the device on which the fan is used.
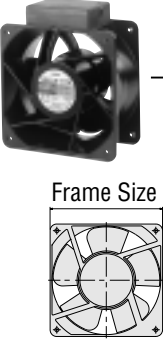
■Guide for Accessories

Here are Accessories to realize easier, more effective fan operation. (page C-14)

1. Select a Fan for Its Size

The case your equipment size has been already settled, and its mounting space for a fan is limited.
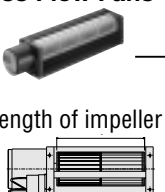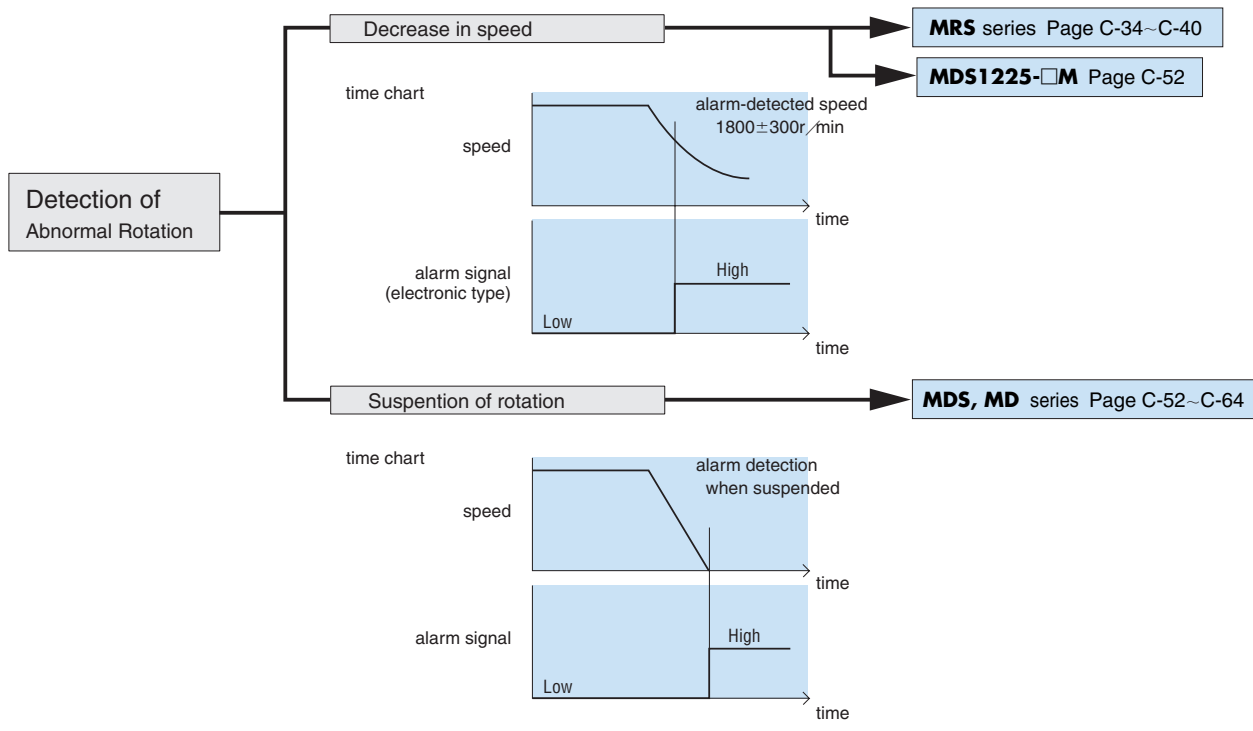Fan Size : frame size, frame thickness, diameter of impeller, etc.

Axial Flow Fans

Frame Size

Frame Size	Frame Thickness	For AC	For DC
7.87"sq.	3.54"	Page C-34	
7.09"sq.	3.54"	Page C-36	
6.77"dia.	2.01"		Page C-50
6.30"sq.	2.44"	Page C-38	
5.51"sq.	1.85"	Page C-40	
4.69"sq.	1.50"	Page C-42	
	.98"	Page C-44	Page C-52
3.62"sq.	.98"	Page C-46	Page C-56
3.15"sq.	.98"	Page C-48	Page C-58
2.44"sq.	.98"		Page C-60
2.05"sq.	.39"		Page C-62
1.65"sq.	.39"		Page C-64

Centrifugal Blowers

Impeller Diameter

Impeller Diameter	For AC	For DC
6.30"dia.	Page C-72	
4.72"dia.	Page C-74	Page C-84
3.94"dia.	Page C-76	Page C-85
3.15"dia.	Page C-78	Page C-86
2.36"dia.	Page C-80	
1.97"dia.	Page C-82	

Cross Flow Fans

Length of impeller

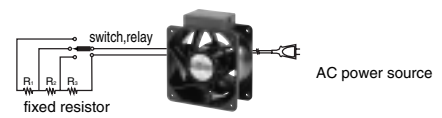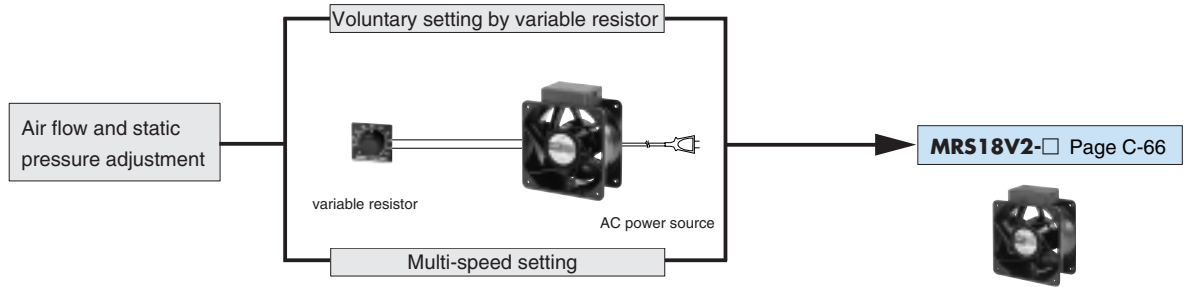| Length of impeller	For AC	For DC
11.81"	Page C-90	Page C-94
5.91"	Page C-92	Page C-96

2. Select a Fan for Its Power Source Specification

The case you would like to use a fan which has the same power source specification as your equipment does, or like to apply its built-in power source to a fan. The case you need a fan which has the same power source specification as your exporting partner uses.

Power Source

- AC
  - Single-Phase 100V~115V
    - Page C-34~ C-61
    - Page C-72~ C-83
    - Page C-90~ C-93
  - Single-Phase 200V~230V
    - Page C-34~ C-61
    - Page C-72~ C-83
    - Page C-90~ C-93
  - Three-Phase 200V~230V
    - Page C-34~ C-41
    - Page C-72
- DC
  - 5 V
    - Page C-62~ C-65
  - 12 V
    - Page C-52~ C-65
  - 24 V
    - Page C-50~ C-65
    - Page C-84~ C-86
    - Page C-94~ C-97

3. Select a Fan for Its Supplementary Functions

The case you need to adjust air-flow to your equipment and static pressure, or input only required air-flow to decrease noise.
The case you need measures against any abnormality of your equipment when the fan has a trouble with its rotation.
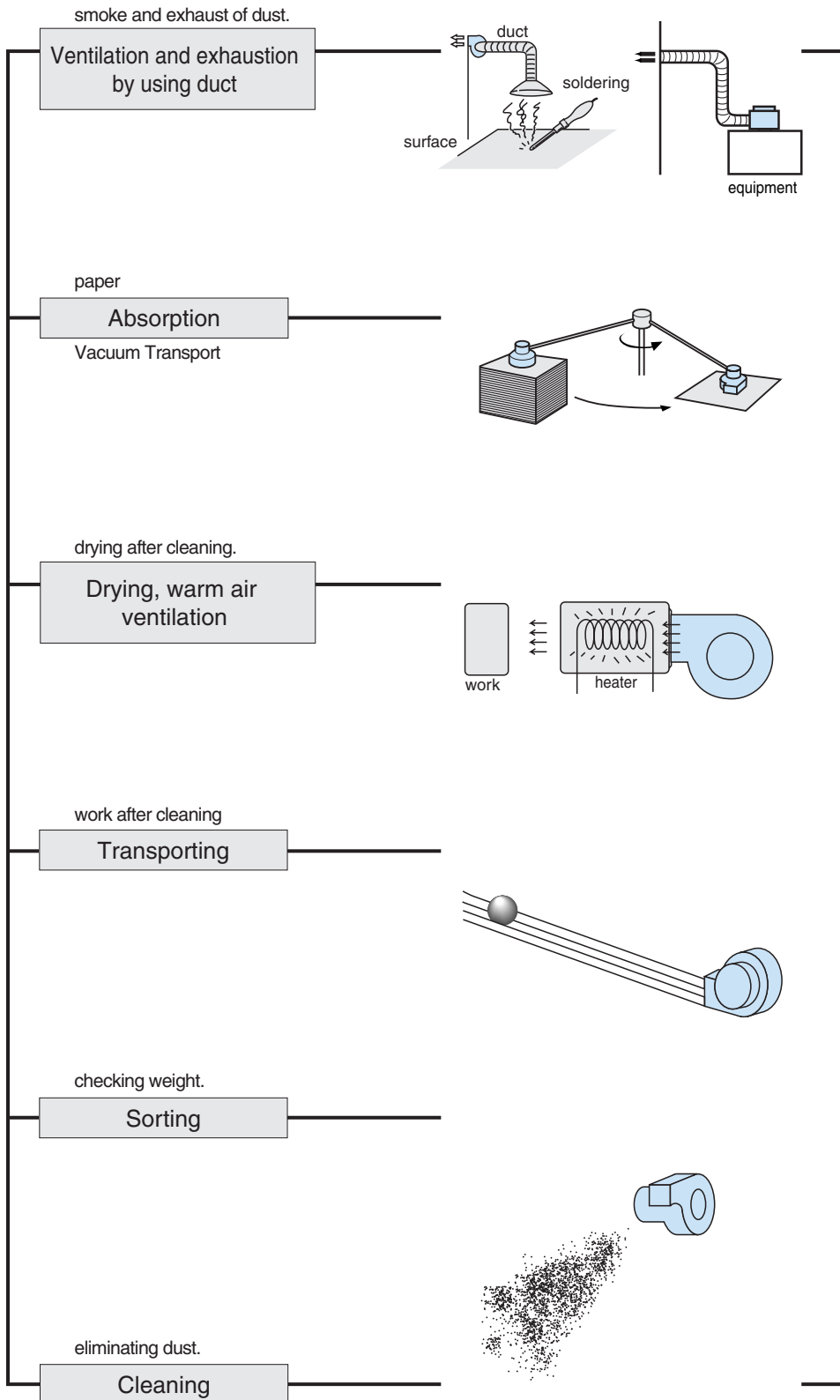
Air flow and static pressure adjustment	Voluntary setting by variable resistor
variable resistor	AC power source
	Multi-speed setting

| switch,relay | AC power source |
| R₁ R₂ R₃ fixed resistor | |

MRS18V2-□ Page C-66

| Detection of Abnormal Rotation | Decrease in speed |

MRS series Page C-34~C-40

MDS1225-□M Page C-52

time chart

speed — alarm-detected speed 1800±300r/min — time

alarm signal (electronic type) — Low / High — time

| | Suspention of rotation |

MDS, MD series Page C-52~C-64

time chart

speed — alarm detection when suspended — time

alarm signal — Low / High — time
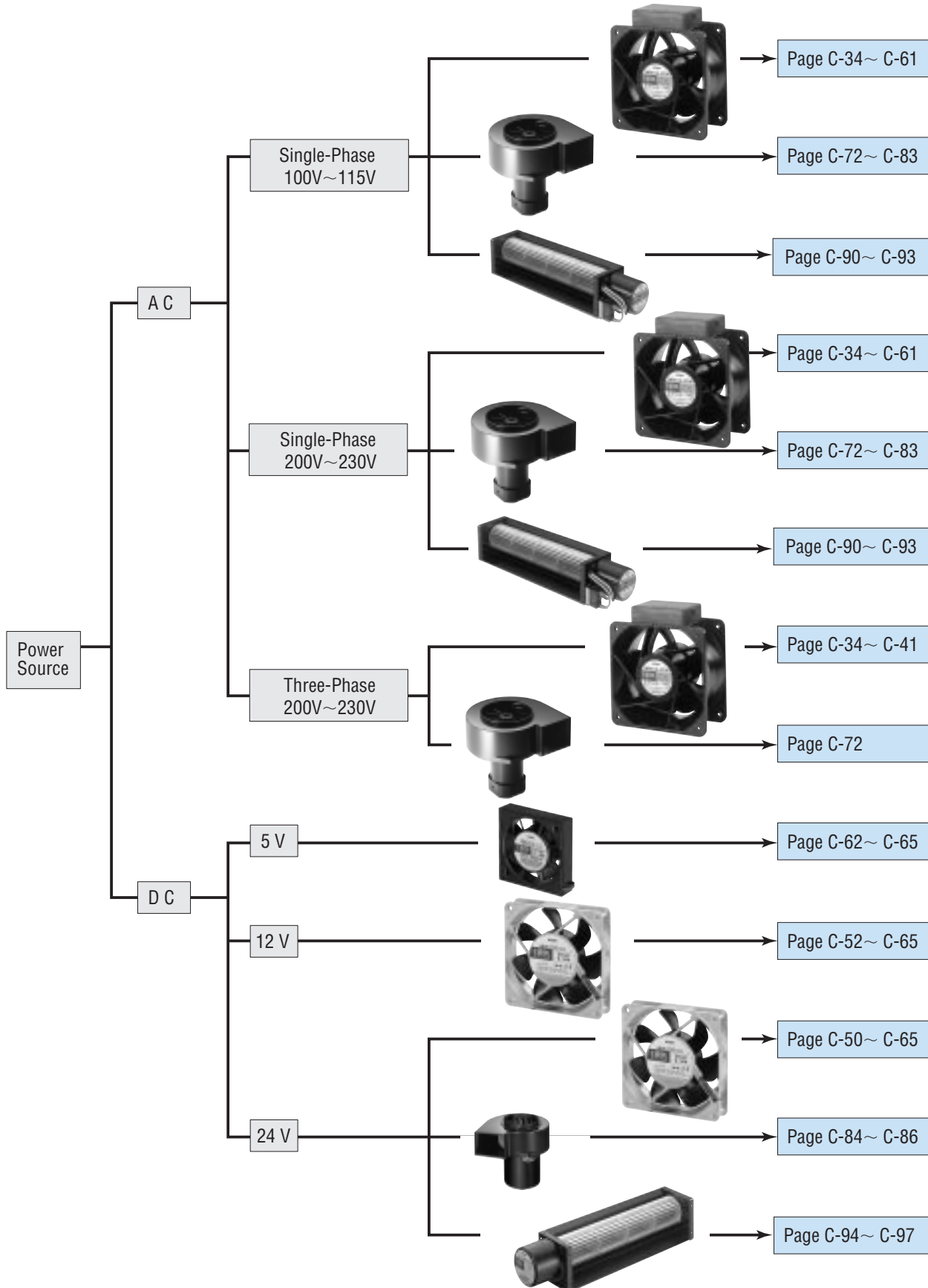
4. Select a Fan for Its Use

An appropriate fan differs depending on its use. Please look at a fan for its use in order to bring out the best in its performance and use it most effectively.

Examples of Cooling Use

Ventilation cooling

large computers and inspection devices.

High-density packaging

→ **MRS** series C-34～C-41

electronic equipment, e.q., measuring devices

Medium- or low-density packaging

→ **MU** series Page C-42～C-49
MDS·MD series PageC-50～C-65

Blow cooling

large motors for machining facility.

Power source

→ **MB** series Page C-72～C-83
MBD series Page C-84～C-86

lighting devices.

Light source

→ **MU** series Page C-42～C-49
MDS·MD series Page C-50～C-65
MB series Page C-72～C-83
MBD series Page C-84～C-86

inside electronic equipment

Parts

→ **MDS·MD** series Page C-50～C-65

heat sink for electronic equipment

Heat sink

→ **MF** series Page C-90～C-93
MFD series Page C-94～C-97

cooling after machining

Work

→ **MB** series Page C-72～C-83
MBD series Page C-84～C-86

cooling of electronic substracte

Flat speed in wide range

Thickness 5.91 in.

Thickness 11.81 in.

Thickness 17.71 in.
(Use 2 fans)

Thickness 23.62 in.
(Use 2 fans)

→ **MF** series Page C-72～C-83
MFD series Page C-84～C-86

Examples of Non-Cooling Use

smoke and exhaust of dust.

Ventilation and exhaustion by using duct

duct

soldering

surface

equipment

paper

Absorption

Vacuum Transport

drying after cleaning.

Drying, warm air ventilation

work

heater

MB series C-72~C-83
MBD series C-84~C-86

work after cleaning

Transporting

checking weight.

Sorting

eliminating dust.

Cleaning
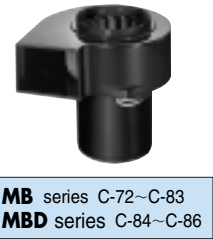
■ Selecting a Fan

This section describes basic methods of selecting typical ventilation and cooling products based on their use.

1. Device specifications and conditions

Determine what in the internal temperature of the device should be.

2. Heat generation within the device

Determine the amount of heat generated internally by the device.

3. Calculate required air volume

Once you have determined the amount of heat generated, the number of degrees the temperature is to be lowered and what the ambient temperature should be, calculate the air volume required.

4. Selecting a fan

Select a fan using the required air flow. The air flow of a mounted fan can be found from the fan's air-flow vs. static-pressure characteristics and pressure loss of the object to be cooled, as shown in Fig 1. It is difficult to calculate the device's pressure loss, so an estimation for the maximum air flow of 1.3 to 2 times the required air flow may be used.
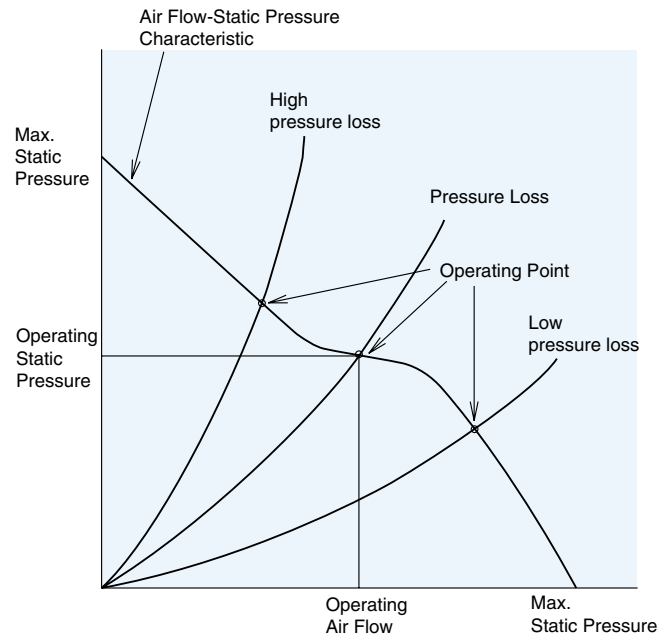
Fig 1.

■ Fan Selection Flowchart

Determine the device's requirements
Determine how many degrees to lower the internal temperature based on the guaranteed operating temperatures of the device's internal components and elements.

↓

Calculate the amount of heat produced
Calculate the amount of heat produced internally.

↓

Calculate the required air flow
Calculate the volume of air required to ventilate the heated air.

↓

Select a fan
Select a fan with a maximum air flow of 1.3 to 2 times the required air volume.

■ Example Selection

In this example, an appropriate cooling fan is selected to cool a DC power supply inside a cabinet.
The fan's power comes directly from an AC power supply, so select an AC fan.

Output: Po=DC24V, 7.5A
Efficiency: η=70%
Maximum temperature within the device: maximum 158˚F
Ambient temperature: 86˚F
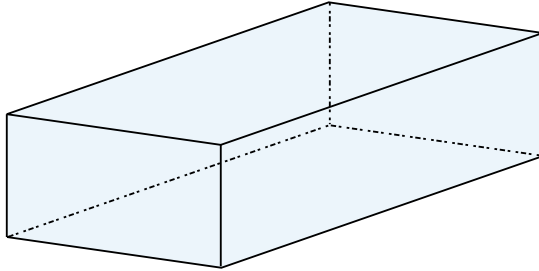
Cabinet with DC power supply

① Heat Generated Within Device

With an output of Po (W), an efficiency of η and a loss of P_L (W):

$$P_0 = \eta \cdot (P_0 + P_L)$$
$$P_L = P_0 \cdot \frac{1-\eta}{\eta}$$
$$= 24 \times 7.5 \times \frac{1-0.7}{0.7} = 77(W)$$

Therefore, the loss is 77 (W). If all of this is converted into heat, and
1 (W) = 3.41 (BTU/Hr)
then
77 × 3.41 = 263 (BTU/Hr)
of heat is generated.

② Calculate the Required Air Flow

$$V = \frac{Q}{\gamma \cdot C_p \cdot (T - T_a)}$$
$$= \frac{263}{0.07 \times 0.24 \times (158 - 86) \times 60}$$
$$= 3.6 \, (CFM)$$

Where,
The required air flow is: V (CFM)
The heat generated is: Q (BTU/Hr)
The specific weight of air is: γ (about 0.07 lbf/ft^3)
The specific heat of air is: Cp (about 0.24 BTU/lbf deg F)

③ Select a Fan

Select a fan with a maximum air flow twice that of the required air flow found in step ②. The **MU825S-23** has a maximum air flow of 15.9 (CFM), which is larger than 3.6 × 2 = 7.2 (CFM).

④ Check the Temperature Within the Device

Check the temperature within the device when the **MU825S-23** is used. If the ventilated air flow is half the fan's maximum air flow, or 7.95 (CFM), then

$$T = \frac{Q}{\gamma \cdot Cp \cdot V \cdot 60} + Ta$$
$$= \frac{263}{0.07 \times 0.24 \times 7.95 \times 60} + 86$$
$$= 119˚F$$
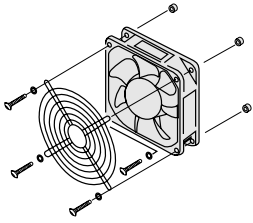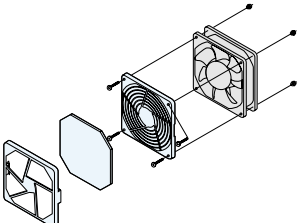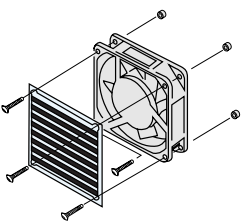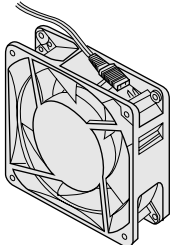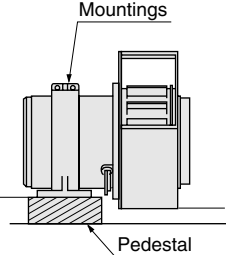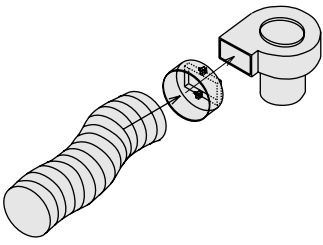
Since the design target is 158˚F, there is a margin of 39˚F.

■ Guide for Accessories

■ Accessories

○ = Available

Accessories / Fan Types	Finger Guards C-100	Filters C-103	Screens C-106
Axial Flow Fans	○	○	○
Centrifugal Blowers	○	○	—
Cross Flow Fans	○	—	—
Overview of Accessories	It is dangerous to insert fingers or other objects into the operating fan blades. Finger guards can improve safety by preventing the insertion of such objects. All fan guards conform to safety standards.✳	Fans intake airborne dust into the machine, where it may accumulate. Filters block the dust while allowing the air to pass through.	Electronic devices can leak electromagnetic waves from their cooling ports, possibly damaging other equipment. Screens partially block the electromagnetic waves while allowing air to pass through.

Accessories / Fan Types	Plug Cords C-107	Mountings C-108	Duct Joints C-109
Axial Flow Fans	○	—	—
Centrifugal Blowers	—	○	○
Cross Flow Fans	—	—	—
Overview of Accessories	These plug-in power cords are used with and **MU** series fans, which use terminal systems in their power supplies.	These devices fix the motors of centrifugal blowers into place.	These are duct joints for connecting the outlet side of centrifugal blowers and the duct.

Mountings

Pedestal

✳ Standards: These products have been designed to pass tests set forth under the UL and CSA standards for equipment used in fans. They conform to the standards only when used on an **ORIX.**FAN.

Q&A Questions and Answers About Cooling Fans

Q1. Can fans be used above the operating voltage range?

A1. AC and DC fans are designed to be used only within their specified operating voltage range.

Q2. Are fans, like motors, equipped with overheat protection devices?

A2. All AC fans in the ORIX.FAN line that meet UL, CSA and EN/IEC standards either have motors with impedance protection or are equipped with a thermal protector. The DC fan includes a current detection function in the drive circuit. In the case of abnormalities, the fan input current is controlled to prevent an increase in temperature and thus guard against burning out the fan motor. C-27 for details regarding impedance and thermal protection, and refer to the section on overheating protection devices.

Q3. Is there a simple way to suppress noise emitted by an axial-flow fan?

A3. Normally, fan noise decreases as fan speed decreases. Axial-flow fans (excluding **MRS** series) are available in three speed types: standard-, middle-speed and low-speed. Noise can be reduced by using middle-speed or low-speed fans. For example, to reduce noise while obtaining the same air-flow as a standard speed fan, a large-sized middle-speed or low-speed fan should be used.

Q4. Where should a fan be mounted to achieve the most effective ventilation and cooling?

A4. Three points should be kept in mind when using a fan for ventilation and cooling.
- Do not increase ventilation resistance (Fig. 1).
- Ensure that the air inside the machinery is not stagnant (see Fig. 1).
- Do not create any shortcuts for air to pass through (see Fig. 2).

As shown in Fig.3 below, the ideal fan position is where air flows in one direction, without interference. If these conditions are met, there is no fundamental difference between forced ventilation and blow ventilation, but exhaust is more effective in maintaining a stable internal temperature.

Air is stagnant

Fig. 1 Large ventilation resistance, stagnant air

Fig. 2 Fan draws air from shortest pathways

Fig. 3 Example of effective ventilation and cooling
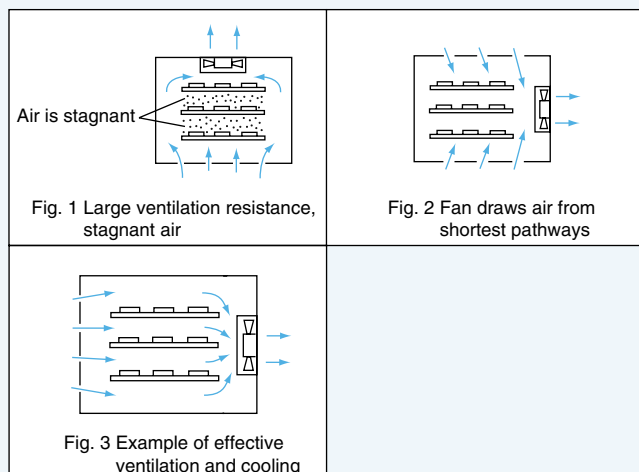
1. *Air Flow vs. Static Pressure Characteristics*

Air flow vs. static pressure curves show the rate of air flow on the horizontal axis and static pressure on the vertical axis. These graphs are used to determine how much static pressure a fan is capable of achieving for a certain rate of air flow. The figure below shows the typical air flow vs. static pressure curve for an axial flow fan. The static pressure (=resistance) is 0 at point A, indicating totally unobstructed air flow. The rate of air flow at this point is called the "maximum air flow". Point B, however, indicates the point where air flow has come to a standstill. This corresponds to the situation where a fan blows into a totally enclosed chamber. The resistance, and therefore the static pressure, reaches its peak value called the "maximum static pressure".

In a practical application, the components to be cooled will offer resistance to the air flowing from the fan to the ventilation openings, thus representing a mid-point with respect to the extreme points A and B. These two points, however, are still useful when the characteristics of different fans are to be compared; they are therefore listed with the technical data of all fans.
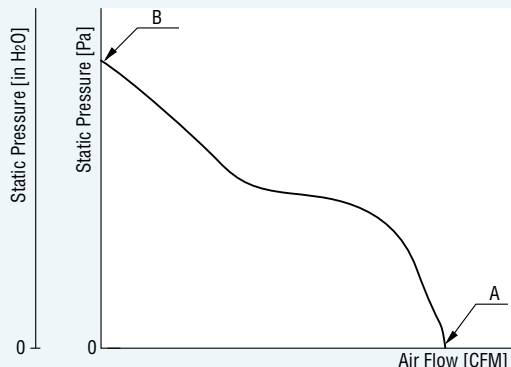
Air flow - static pressure curve

2. *Audible Noise Frequency Analysis*

The type of noise that causes concern with is not a pure sound at a particular frequency like one generated by a tuning fork, but rather a composite sound composed of many frequencies. The 1/3 octave band frequency analysis shown in the figure below is used to determine exactly of which frequencies this composite sound consists. An octave is the interval from one frequency to double that frequency. If the frequency is slightly off, the average human ear cannot detect it; only when the frequency is off by about 1/3 of an octave can the difference begin to be heard. The 1/3 octave band frequency analysis measures sound pressure levels for each 1/3 octave interval as an average value and then graphs those measurements. This allows noise analysis data to mimic human hearing.
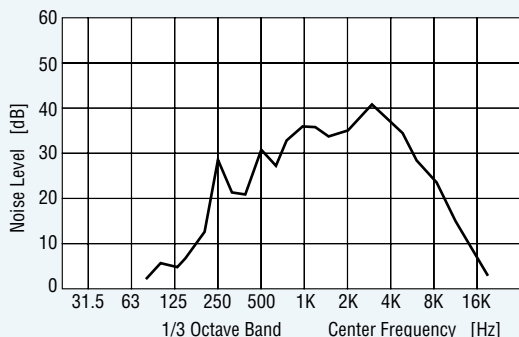
3. *Decibels (dB)*

Noise level is expressed in decibel units (dB). This logarithmic scale is used because it is difficult to express the loudness of noise on a linear scale. For example, if 1 represented the minimum noise audible by the human ear, then the maximum bearable level of noise would be about 5,000,000. In contrast, if noise (level of acoustic pressure) is expressed in decibels, then
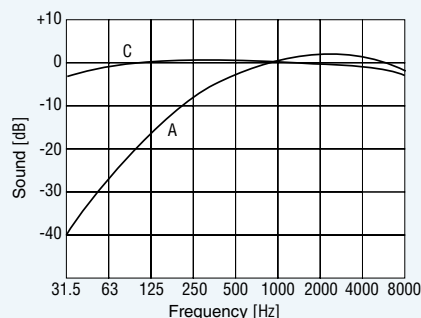
$$\text{Sound pressure level} = 20 \log P/P_0$$

where,
P = Actual acoustic pressure
P_0 = Minimum sound pressure perceptible by the human ear

Therefore, the audible range of sound pressure can be conveniently expressed as $0 \sim 130$dB.

4. *A Range*

It is generally said that the audible range of the human ear is between 20Hz and 20kHz. Another characteristic of human hearing is that sounds at some frequencies are not perceived as loud and irritating. For this reason, an accurate indication of loudness as perceived by the human ear cannot be achieved simply by measuring sound pressure without taking frequency into account. Therefore, measurements of the level of acoustic pressure must be corrected according to frequency in order to accurately reflect human perception of loudness. This corrected range of measured acoustic pressure values is called the A range, which is shown in the graph below. This graph compares the frequency-corrected measured values (A range) with the uncorrected measured values, (C range).

Comparison of Sound Pressure Level

5. *Flammability Classification*

In general, the flammability class of plastic materials used in equipment parts is expressed in UL94 (standard for tests for flammability of plastic materials for parts in devices and appliances). UL standards evaluate flammability in terms of factors such as burning rate after applying a flame and ignition by flaming drops. UL94 classifies flammability as follows.

Classification	Resistance to Flammability
V-0	High
V-1	
V-2	
HB	Low

ORIX.FAN uses blades and frames with materials that receive the highest grade in this classification, V-0

Use of Fans

1. Precautions

● Precautions for Installation

- Do not use in a place where there is flammable gas and/or corrosive gas.
- DC fans are for use in the Class II (for EN60950), low voltage, limited energy circuit (for UL/CSA standard) or in the safety extra low voltage range (for EN60950).
- Fans for use only in equipment of protection Class I (AC fans only).
- Connect the ground wire to the ground terminal inside the terminal box(Terminal box Type only).
- The fan housing must be mounted with a screw and spring washer to the ground point of the equipment(AC fans only).
- When installing the fan into your equipment, ensure that the motor lead wires are fixed and do not move. In addition, do not apply any pressure to these lead wires.
- Installation must be performed by a qualified installer.

● Precautions for Operation

- Always turn off the power to the fan before conducting checks or performing work on the fan.
- Always turn off power to thermally protected fan before conducting checks or performing work on the fan. (Thermally Protected Fans only)
  These types of fans will restart automatically when the fan temperature falls below a certain level.
- The enclosure temperature of this fan can exceed 158°F (70°C), depending on operation conditions.
  Warning label
  In case the fan is accessible during operation, please attach the following warning label so that it is clearly visible.
- Do not touch the fan blades when the fan is in operation. The use of the optional finger guard is recommended to ensure protection.

2. Mounting the Fan

These fans can be oriented such that air is blown either horizontally or vertically. In addition, they can be mounted against either the outlet or inlet.

Horizontal mounting against the outlet
Fan
Outlet
Intake
Inside machinery

Vertical mounting against inlet
Intake
Outlet
Fan
Inside machinery
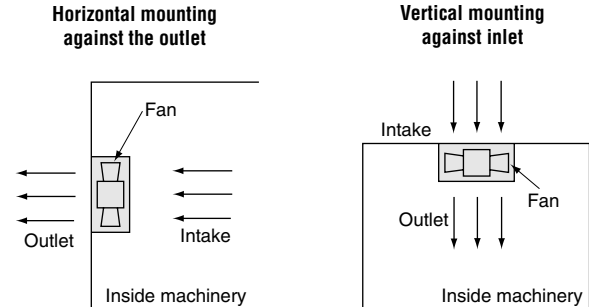
3. Mounting Fans in Machinery

● Axial Flow Fans

To mount the fan in machinery, drill suitable mounting holes in accordance with the mounting hole dimensional diagrams given on the same page as the product (for some fans, the shape the mounting holes is different for inlet and outlet mounting).
To prevent vibration, mount the fan securely to a strong metal plate. Mounting screws are not included with the fan. Use screws of suitable size, referring to the fan's external dimensions and the mounting hole dimensional diagrams.
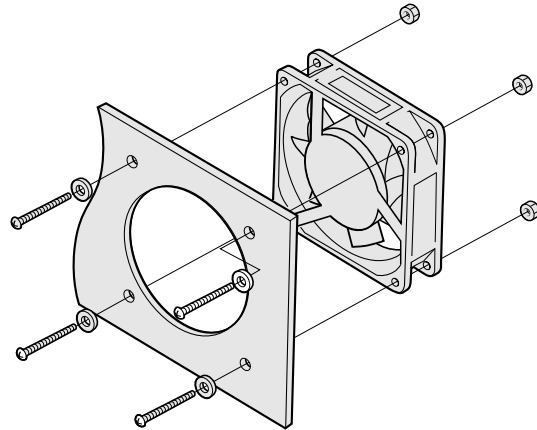
Recommended Tightening Torque

| Model	Screw Dimensions	Tightening Torque oz-in (N·m)
MRS series (except for **MRS14**)	M5	169.93 (1.2)
MRS14 type	M4	84.97 (0.6)
MU series (except for **MU925**)	M4	84.97 (0.6)
MU925 type	M3	56.64 (0.4)
MDS•MD series (except for **MD625, MDS510, MDS410**)	M4	84.97 (0.6)
MD625, MDS510, MDS410 type	M3	56.64 (0.4)

●Centrifugal Blowers

① Using special mountings

Special mountings (sold separately) matched to the diameter of the motor case can be used to mount the blower in place.

For all the blowers except **MB520** and **MB630**, h2 is longer than h1, therefore, a pedestal must be used when mounting the blower so that the casing does not touch the surface to which the fan is fixed.
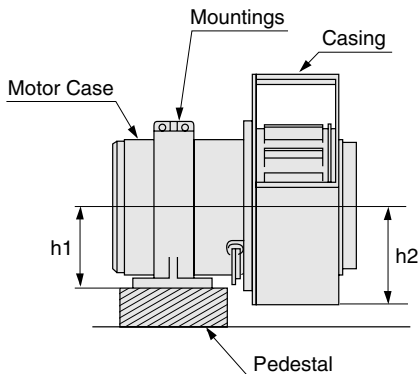
② Attaching blowers directly to the machine using screws
(For **MB520** and **MB630** only)

Mounting holes are provided in three spots on the **MB520** and **MB630** casings so the blowers can be fixed to the machine with no extra mounting equipment. Refer to the panel cut-out on the blower page for dimensions to drill mounting holes.
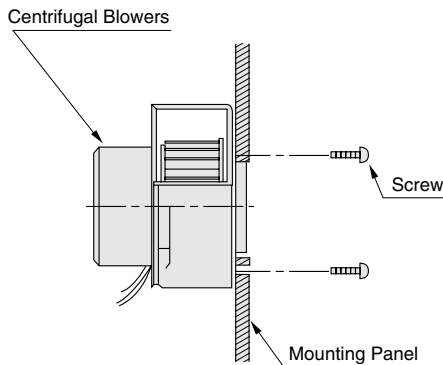
Recommended Tightening Torque

Model	Screw Dimensions	Tightening Torque oz-in (N·m)
MB630 type	M3 P0.5 Length=t+3.5mm	84.97(0.6)
MB520 type	M3 P0.5 Length=t+2.5mm	

t: Thickness of mounting plate

●Cross Flow Fans

Cross flow fan casings have mounting holes on all sides.
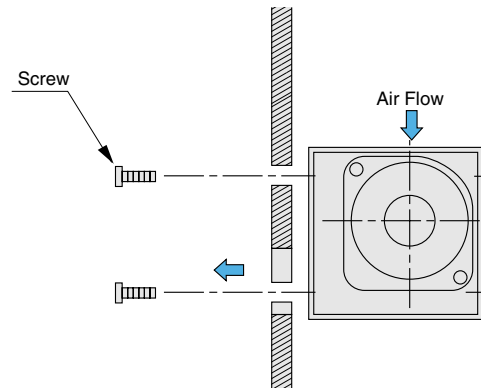
Refer to the panel cut - out on the cross flow fan page for dimensions to drill the mounting holes.

Recommended Tightening Torque

Model	Screw Dimensions	Tightening Torque oz-in (N·m)
MF•MFD series	M4 P0.7 Length=t+5mm	198.26 (1.4)

t: Thickness of mounting plate

4. Mounting Locations

Install the fan and capacitor in locations that meet the following conditions:

· Indoors (the product is designed and manufactured to be mounted in a machine.)
· Ambient temperature 14˚F~140˚F (14˚F~108˚F for **MB** series) (Nonfreezing)
· Ambient humidity 0~85% (Noncondensing)
· No explosive, flammable and/or corrosive gas.
· No exposure to direct sunlight.
· No splashing water, or exposure to dust or debris.
· No oil or grease, organic solvents, acid or alkaline chemicals.
· No continuous vibration or excessive shock.
· Installation category Ⅱ, Pollution degree 2, Class Ⅰ equipment (EN/IEC standard) (AC fans only).
· Installation category Ⅰ, Pollution degree 2, Class Ⅲ equipment (EN/IEC standard) (DC axial flow fans only).

5. Installing Accessories

Dust or objects entering the machinery through the fan opening can affect the life of the machinery and cause accidents. To ensure safety and maintain performance, it is recommended that options such as finger guards, filters, screens and duct Joints be installed on fans. Refer to the installation instructions given on the following pages.
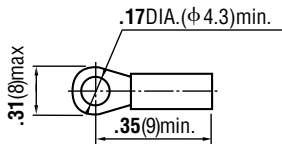
6. Connection to Power supply

● MRS Series

MRS (excluding **MRS20**) series fans use a terminal box for the power supply connection and Protective Earth (P.E.) connection, allowing the power supply cord and Protective Earth (P.E.) cord to be fastened securely. If possible, use a crimp-style terminal to connect the cord to the terminal box. Also, when connecting the power supply for fans that include alarm circuits with single-phase voltage specifications, be sure to connect the capacitor provided.

Crimp-style Terminals that can be used
Unit = **inch** (mm)

Round terminal type with insulation

.17DIA.(φ4.3)min.
.31(8)max
.35(9)min.

U-shaped terminal type with insulation

.17(4.3)min.
.31(8)max
.35(9)min.
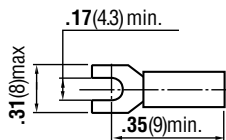
● MU Series

Terminals for connection to the power supply and Protective Earth(P.E.) are located in the fan frame. Using the optional power supply cord makes connections easy.
Use an M4×8 mm screw and washer for the P.E. (Protective Earthing Terminal).
The **MU825** type has lead wire output, so no plug cord is required.
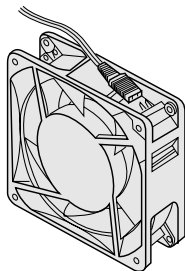
● MDS, MD, MBD, MFD Series

Use the black and red lead wires extending from the fan.
Connecting the red wire to the plus (+) terminal and the black wire to the minus (−) terminal. (This applies to all DC axial-flow fans.)
Even if connections are reversed by mistake, the fan is equipped with a protection circuit to keep current from flowing in the wrong direction.
For the **MDS·MD** series, use a DC power source with reinforced insulation with the primary side.

Black
DC V
Red
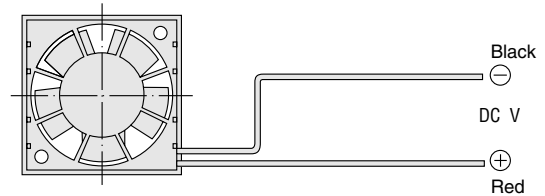
7. Speed Adjustment

The DC fan can be operated within the usage voltage range. When the input voltage is varied within this usage voltage range, the rotation rate varies proportionally to the voltage and the fan air flow characteristic also varies.

MD825B-24
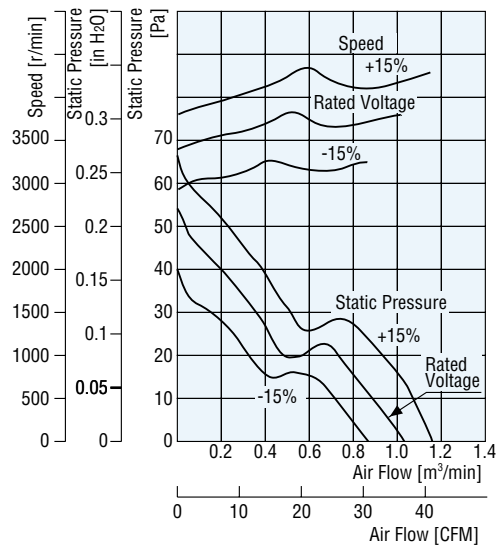
8. *Alarm Circuits*

The **MRS** and **MDS•MD** series include fans equipped with built-in alarm circuits that activate when the fan air flow capacity declines. The following is an explanation of these alarm detection systems.

●Electronic Output Alarm Circuits

① Models with Alarm Circuits

Alarm Functions	Series	Model
Low-speed alarm type	**MRS** Series	**MRS20-BM, MRS20-DM, MRS20-TM, MRS18-BTM, MRS18-DTM, MRS18-TTM, MRS16-BTM, MRS16-DTM, MRS16-TTM, MRS14-TTM**
	MDS Series	**MDS1225-12M, MDS1225-24M**
Stall alarm type	**MDS** Series **MD** Series	**MD925A-12L, MD925A-24L, MD825B-12L, MD825B-24L, MD625B-12L, MD625B-24L, MDS510-12L, MDS510-24L, MDS410-12L, MDS410-24L**

② Detection System

· **Generator Voltage Detection System**

With this system (used in the models except **MRS14**), speed is detected from the voltage produced by the generator mounted on the rotation shaft. The alarm circuit is driven by this voltage and therefore requires no other power supply. However, the system requires an external start delay circuit to prevent alarms from being output during the period immediately after starting when the fan speed is below the alarm activation speed.

· **Hall effect sensor Detection System**

With this system (used in the **MRS14**), speed is detected by means of a magnet mounted on the rotation shaft and hall effect sensor. The system requires a power supply (DC5V,±5%) for driving the alarm circuit. When this power supply circuit is turned on, the alarm function begins monitoring within 25 seconds. No alarm signals are output at this time since the alarm circuit incorporates a start delay circuit.

· **Detection System in DC Brushless Fan**

DC brushless fans use a system that detects speed by means of the stator coil's ON/OFF frequency. The alarm circuit is driven by the fan's power supply. **MDS**, **MD** series fan output an alarm signal when the fan starts up (except the **MDS1225**), so they require an external start up delay circuit. **MDS1225** type fan, when the fan is turned on, the alarm function begins monitoring within 10 seconds. No alarm signals are output at this time since the alarm circuit incorporates a start delay circuit

③ Electronic (open collector) Output System

With this system, alarms are output through transistor control. The system uses no mechanical contacts or moveable parts, eliminating contact noise and increasing reliability.
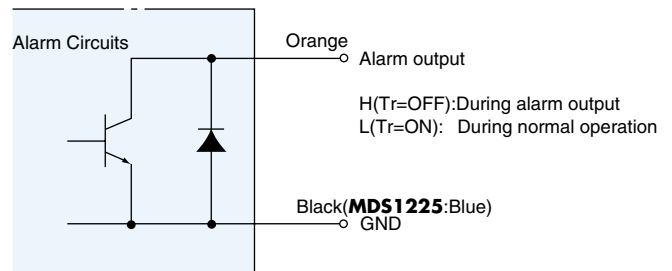
Maximum Output Voltage	$V_{out} = 30$ V max.
Output Leakage Current	$I = 250$ μA max.
Maximum Output current	$I_{out} = 15$ mA max. (Stall alarm type: $I_{out} = 5$ mA max.)
Output Saturation Voltage	V_{out} (sat) $= 0.4$ V max.

④ Alarm Activation Speed

● Low-speed alarm type:
  When fan speed falls bellow 1800±300 r/min, an alarm signal (high-level) is output.

● Stall alarm type:
  If the fan stops rotating, an alarm signal (high-level) is output.

●Contact Output Alarm Circuits

① Models with Alarm Circuits

| Series	Model
MRS Series	**MRS16-BTA, MRS16-DTA, MRS16-TTA**

② Detection Method

• Generator Voltage Detection Method

Speed is detected from voltage produced by a generator mounted on the rotation shaft. The alarm circuit is driven by this voltage and, therefore, requires no other power supply. However, the system requires an external start delay circuit to prevent alarms from being output during the period immediately after starting when the fan speed is below the alarm activation speed.

③ Contact-type (lead relay) Output System

Using the voltage produced by the generator, the relay contact built into the alarm circuit is switched via a transistor.
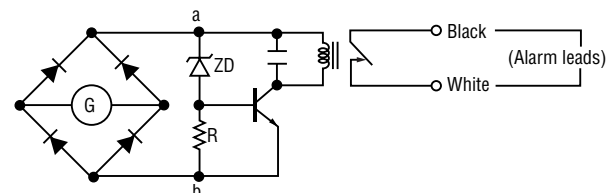
Fault State	Contact ON
Normal State	Contact OFF
Contact Capacity	Resistance load MAX. 10VA (MAX.100V/MAX.0.5A)

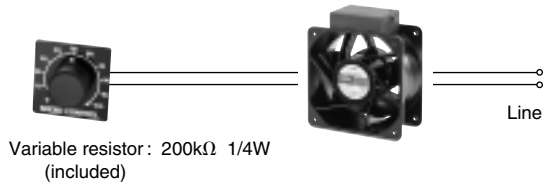### ④ Alarm Activation Speed

When fan speed falls bellow 1800±300 r/min, an alarm signal is output.

9. Use of Variable Flow Fans

●Operation of **MRS18V2**

①**When adjusting the speed with the variable resistor**
Connect the variable resistor to the lead wire coming out of the fan terminal box.
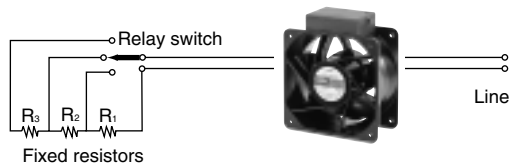
Variable resistor : 200kΩ 1/4W
(included)

Note: Do not run a series of fans off a single Variable resistor.
Circuit damage may result.

②**When adjusting the speed continuously with external fixed resistors**
Relays can be used to switch between fixed resistors to adjust the speed of the fan.
R1＋R2＋R3＝200kΩ(max.)1/4W(min.)

●Speed setting variable resistor

A maximum voltage of 100V can be applied across the terminals of the variable resister. If the variable resistor is used in an area with high electrical noise, the speed may fluctuate. Should this occur, try any of the following solutions:
● Put a noise filter on the power source line.
● Use twisted pair wire for the wiring.
● Route the wire as far as possible from lines generating noise (lines with large current flows).
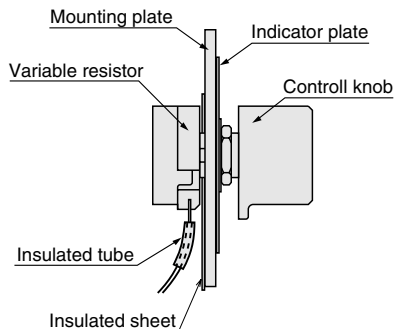
Note: The indicator plate, control knob and insulated sheet are included with the variable resistor.

Technical Notes

■ Air Flow - Static Pressure Characteristics

1. Pressure Loss

When air flows along a certain path, a resistance (called "air flow resistance") is produced by anything in the path that inhibits that flow. Comparing the cases illustrated in Fig.1 and Fig.2, we see that the device shown in Fig.1 is almost empty, so there is almost no air flow resistance in the device and little decline in the air flow. By contrast, there are many obstructions of the air flow in the device shown in Fig.2, which increases air flow resistance and decreases air flow.

This situation is very similar to the role of impedance in the flow of electrical current: when impedance is low, the current flow is large, when impedance is high, the current flow is low.
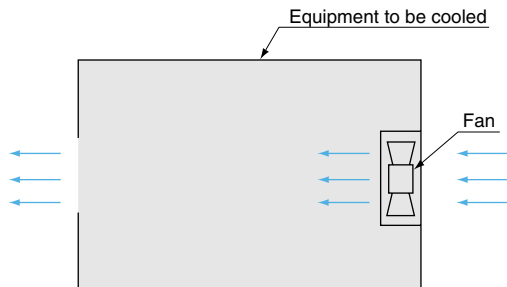
Fig. 1 Flow path with low air flow resistance
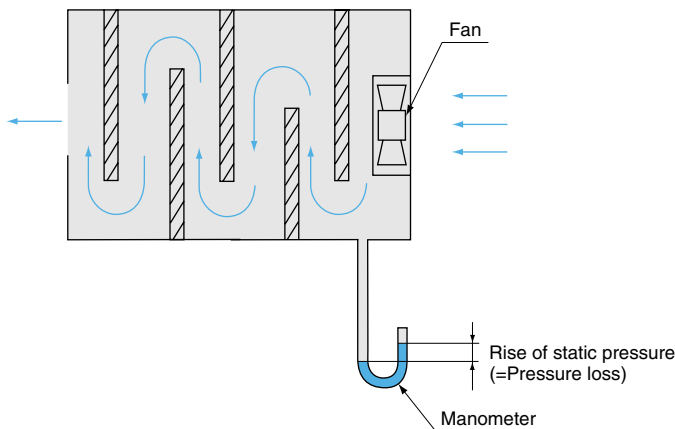
Fig. 2 Flow path with high air flow resistance

The air flow resistance becomes the pressure energy that increases the static pressure inside the device and is called pressure loss. Pressure loss is determined using the following equation,

Pressure Loss
$$P = \frac{1}{2}\xi V^2 \rho$$
$$= \frac{1}{2}\xi \left(\frac{Q}{A}\right)^2 \cdot \rho$$

where
V : Flow speed [m/s]
ρ : Air density [kgf·s^2/m^4]
ξ : Resistance factor (particular to the device)
A : Cross sectional area of the device [m^3]
Q : Air flow [m^3/min]

In terms of the fan, this equation says that to achieve a certain air flow (Q), the fan must be able to supply a static pressure sufficient to increase the pressure inside the device by

$$P = \frac{1}{2}\xi \left(\frac{Q}{A}\right)^2 \cdot \rho$$

2. Air Flow - Static Pressure Characteristics

Fan characteristics are generally expressed in terms of the relationship between air flow and the static pressure required to generate such air flow, and given as an air flow vs. static pressure characteristic curve.

As an example, say the air flow required is Q_1, and the accompanying pressure loss of the device is P1. When the fan characteristics are as shown in Fig.3, the fan is capable of a static pressure of P_2 at an air flow of Q_1. This is more than sufficient for the required air flow since it exceeds the required static pressure value of P1.
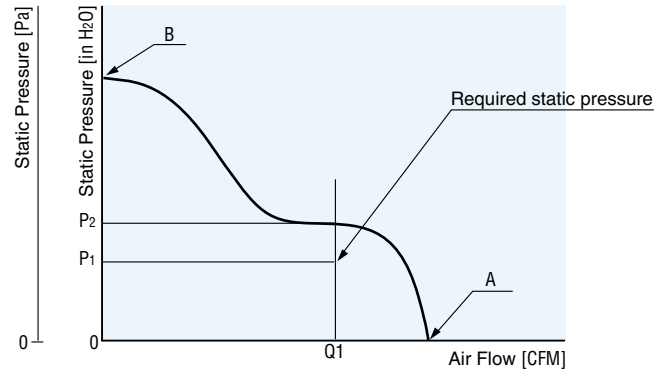

Fig. 3 Air flow-static pressure characteristics

At point A in Fig. 3, the static pressure is 0, meaning there is absolutely no pressure loss and the air flow the fan can deliver is at its maximum. The air flow at this point is called the maximum air flow.

At point B, on the other hand, the pressure loss is so large that air flow is 0. This point is called the maximum static pressure. In actual applications, however, the fan will not be used with maximum static pressure or maximum air flow. Although maximum static pressure and maximum air flow are used as fan specifications, they are in fact only important for the comparison of characteristic values.

Since pressure loss is proportional to the square of the air flow, if air flow is needs to be doubled, the fan chosen must be capable not only of twice the air flow but of four times the static pressure as well.

3. Measuring Air Flow - Static Pressure Characteristics

There are two methods for measurement of the air flow vs. static pressure characteristics: one using a wind tunnel and pitot tubes, and the other using a double chamber. Oriental Motor uses the double-chamber method because its higher accuracy has greater international acceptance. Oriental Motor's measuring set-up is based upon the authoritative standard 210 of the AMCA (Air Movement and Control Association). It measures the air flow and air pressure generated by a given fan (see Fig. 4) by measuring the pressure difference above and below the nozzle (Pn) and that within the chamber (Ps).
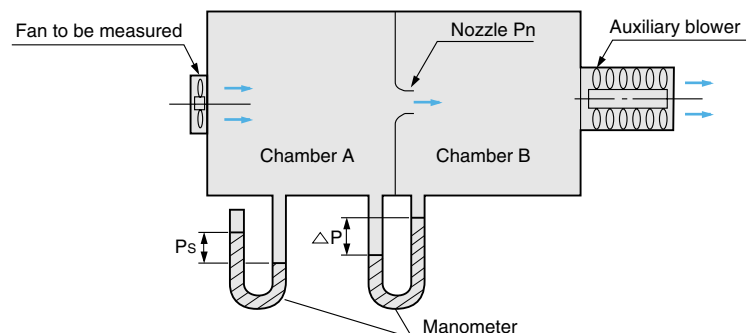

Fig. 4 Double chamber measuring set-up

Since this method allows the speed of the fluid flowing through the nozzle to be determined from the pressure differential between chamber A and chamber B, the air flow (Q) can be expressed as a product of the flow speed (v) through the nozzle, the nozzle area (A) and the flow coefficient (C).
Thus,

$$Q = 60CAv$$

$$= 60CA\sqrt{\frac{2g\Delta P}{\gamma}} \text{ [m}^3\text{/min]}$$

where
A: N:ozzle sectional area [m^2]
C: Fluid coefficient
v: Average flow speed at the nozzle [m/s]
γ: Specific gravity of the air [kg/m^3]
   (at 68°F and one atmosphere $\gamma = 1.2$kg/m^3)
g: Acceleration due to gravity = 9.8 [m/s^2]
Δp: Pressure differential [mmAq]

Measurement of the air flow vs. static pressure characteristics uses an auxiliary blower to control the pressure in chamber B, altering the pressure in chamber A. Thus, each point on the characteristics curve can be measured. The Oriental Motor measuring equipment is connected to a computer, enabling highly precise measurements in a short period of time.

4. Change in Characteristics when Installing Two Fans

Air flow and static pressure of two fans with identical characteristics will vary greatly depending on whether the fans are installed in series or in parallel.
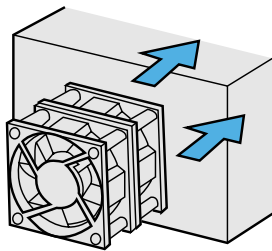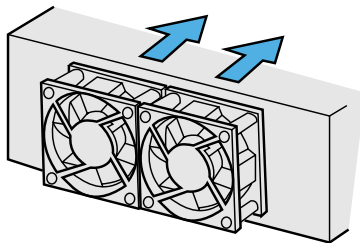

Fig.5 Installing two fans in series

Fig.6 Installing two fans in parallel

MU1238A-51B
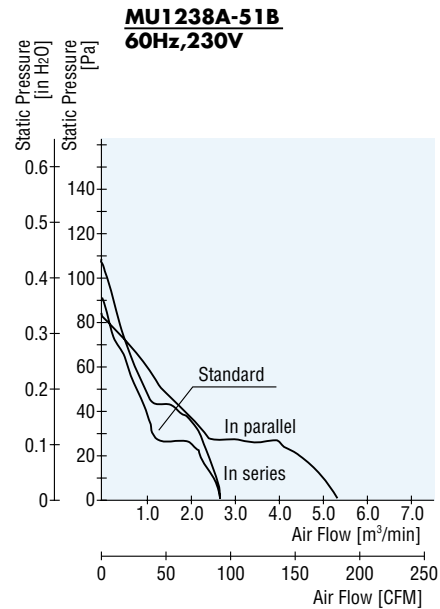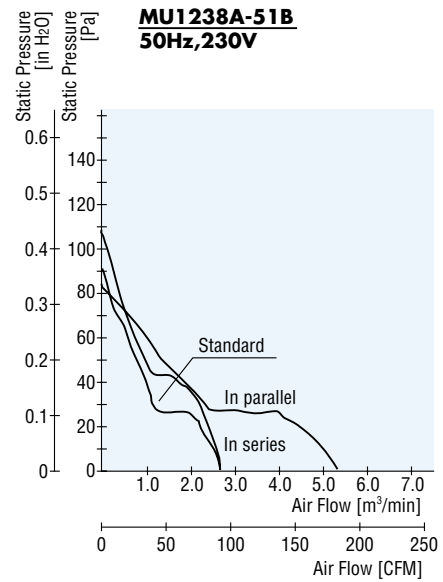**50Hz,230V**

MU1238A-51B
60Hz,230V

Fig.7 Characteristics for different installation methods

As shown in the graphs, fans installed in series generate greater static pressure, while fans mounted in parallel provide double the air flow.

5. Change in Characteristics By Installing Optional Parts

When installing the fan in equipment, the safety and reliability of the overall apparatus can be improved considerably by attaching optional parts such as finger guards or filters. However, these optional parts produce air flow resistance, affecting fan characteristics and fan noise. This factor should therefore be taken into account when selecting fans and optional parts.

There is shows pressure loss when optional parts are attached to a fan. Loss is greatest with a filter, and practically negligible with the finger guard. For an example of pressure loss, see Fig.8.
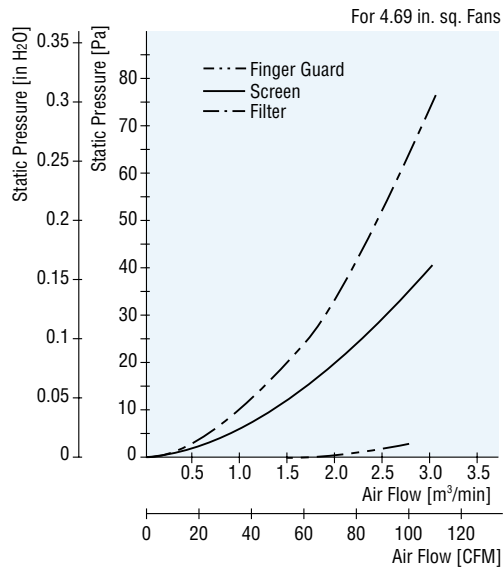
For 4.69 in. sq. Fans

Fig.8 Pressure loss due to optional parts

Fig.9 shows how characteristics may change with the installation of optional parts, using the **MU1225S-21** as an example.
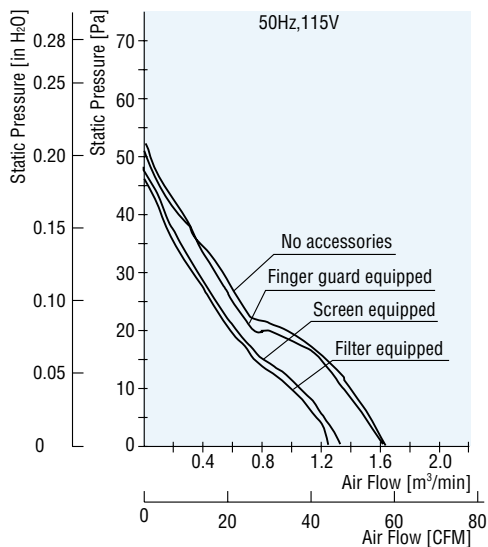
60Hz,115V

No accessories
Finger guard equipped
Screen equipped
Filter equipped

50Hz,115V

No accessories
Finger guard equipped
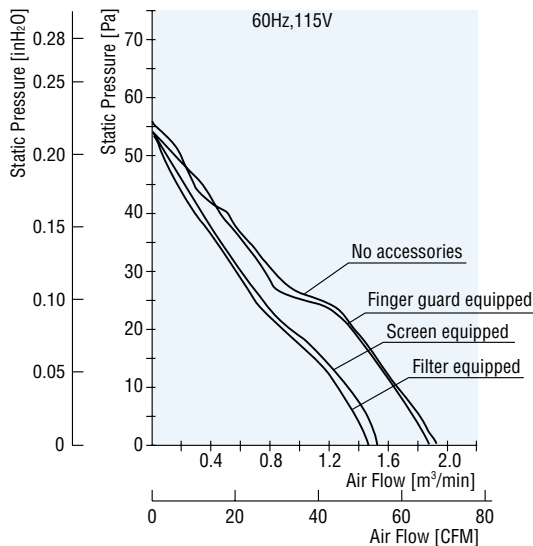Screen equipped
Filter equipped

Fig.9 Changes in characteristics with optional parts attached to the MU1225S-21

As the graphs show, the larger the pressure loss caused by optional parts, the greater the reduction in air flow and static pressure characteristics.

■ Audible Noise

1. *Audible Noise*

We generally call sounds that are unpleasant to us "noise". In the case of fans, noise is generated as the rotation of the fan blades causes a change in air pressure. The greater the change in air pressure, the louder is the noise produced.

2. *Measuring Audible Noise*

The noise of Oriental Motor fans is measured in the A range at a distance of 3.3 feet (1m) from the intake (at a point above the center line of the intake).
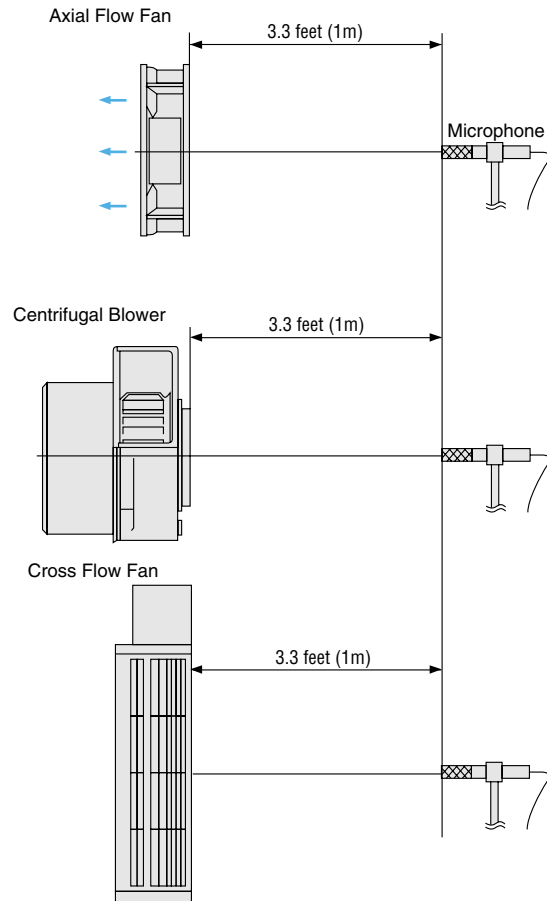
Axial Flow Fan

3.3 feet (1m)

Microphone

Centrifugal Blower

3.3 feet (1m)

Cross Flow Fan

3.3 feet (1m)

Fig.10 Measurement of fan noise

3. Combined Audible Noise

Noise, or relative loudness, is expressed in decibel units, and combined noise cannot be determined simply by adding individual noise levels. The value that expresses this combined noise is found by determining the energy of the noise, and then using it to calculate the increase in sound pressure. If J denotes acoustic energy and P sound pressure, the relationship between the two values is given by the following equation:

$$J = \frac{P^2}{\rho c} \ ,$$

ρ: Air density
C: Speed of sound
where ρ is equal to the air density and c is equal to the speed of sound propagation. This expression can be used to find the loudness in decibels as follows:

Sound pressure level $= 20 \log P/P_o$
$= 10 \log J/J_o$
P: Actual sound pressure
J: Measured acoustic energy
P_o, J_o: Minimum acoustic energy audible by the human ear

Thus, this expression gives the noise level in decibels based on the audible acoustic energy J_o. This expression can be used to calculate the sound pressure for two or more fans operated simultaneously. If n is the number of fans, then n times the amount of acoustic energy is produced, as follows.

Noise level $= 10 \log n \cdot J/J_o$
$= 10 \log J/J_o + 10 \log n$

In other words, when n fans are operated simultaneously, the increase in noise is equal to $10 \log n$ (dB).
In this example, if two 40dB fans ($n=2$) are operated simultaneously, the increase in noise level is equal to $10 \log 2$ or 3dB, and the combined noise level is 43dB.
What would be the combined noise level be if a 40dB fan and a 50dB fan were operated together? Again, the combined noise level is not given by the simple arithmetic sum, but obtained as follows (also refer to Fig. 11):

Take the difference between the two noise levels: 50dB − 40dB = 10dB

↓

At the 10dB point on the x-axis of the graph find the corresponding point on the curve and read the y-axis value: 0.4dB.

↓

Add 0.4 to the larger of the two noise levels, 50dB.

↓

The combined noise level when operating the two fans simultaneously is 50.4dB.

If 40dB of noise is combined with 50dB, the resulting increase in noise is only 0.4dB. Thus, when fans of different noise levels are operated simultaneously, it is more important to reduce noise from the fan with the higher noise level.
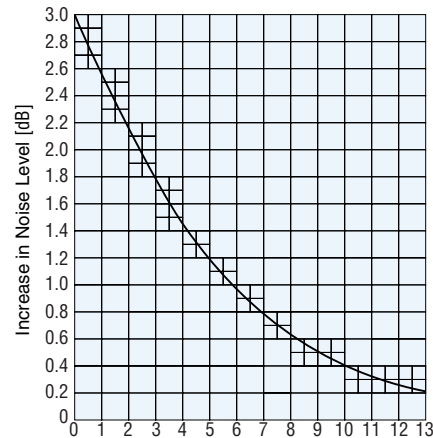

Fig. 11 Combined Noise

4. Relationship Between Audible Noise and Distance

The noise level decreases as the distance from the source of the noise increases. The decrease in noise due to distance is given by the following expression:

$$SPL_2 = SPL_1 - 20 \log r_2/r_1$$

where,
SPL_2: noise level at distance r_2
SPL_1: noise level at distance r_1

In the following example, the noise level at a point 6.6 feet (2m) from a fan whose noise level is 40dB at a point 3.3 feet (1m) from the intake side will be calculated.

Since $r_2 = 6.6$ feet (2m), $r_1 = 3.3$ feet (1m), and $SPL_1 = 40$dB, substituting in the expression gives

$$SPL_2 = 40 - 20 \log 2/1$$
$$= 34\text{dB}.$$

Thus, at a distance of 6.6 feet (2m), the noise level decreases by 6dB.
The value $20 \log r_2/r_1$ in the above expression represents the ratio between two distances. Thus, if the values used above were 9.9 feet (3m) and 19.7 feet (6m), the result would have been the same. Therefore, if the noise level at a certain distance is known, the noise level at another distance can be estimated.

■ Fan Life

1. Fan Life

Fan life refers to the period that a fan can be operated continuously without losing ventilating capacity or emitting so much noise that it cannot be used. Therefore, there are two components of fan life:

Fan Life
① Rotation life: Defined as the period the fan can be operated before rotation decreases by a certain value.
② Acoustic life: Defined as the period the fan can be operated before noise increases by a certain value.

Rotation life can be easily measured so long as the factors involved can be clearly specified numerically; this is usually what is meant when referring to fan life. Acoustic life, however, is defined by the increase in decibel level, and determining exactly what amount of increase marks the end of acoustic life depends on the judgment of the user. Moreover, fans can still meet operating requirements even after reaching the pre-determined increase in noise. In general, then, standards relating to noise and the length of acoustic life have not been established.

Oriental Motor defines fan life by rotation life; a fan is judged to have reached the end of its service life when rotational speed declines to 70% of the rated speed.

2. Product Life

The following is a description of the fan parts that are most important in determining fan life, beginning with the relationship between time and failure rate.

Generally, when parts have been used for a long time, their failure rate relative to the duration of use fits the pattern of the curve shown in Fig. 12 below.

The first period is the initial failure period in which sub standard parts tend to break down. The second period is called the accidental failure period, characterized by a highly stable, low failure ratio. If this period were to continue the forever, the part's life would not be a concern. However, depending on the part, the failure rate increases again, and enters a third period called the friction fault period.
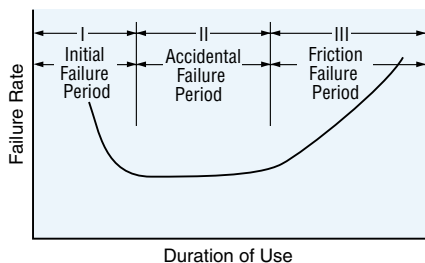

Fig. 12 Relationship between the duration of use and failure rate

Bearings are the parts within a fan whose life is most affected by this friction failure period. Therefore, fan life could be said to be determined by the life of the bearings used.

3. Fan Bearing Life

The following is an explanation of the factors involved in the life of ball bearings, which are the type of bearings used in most fans.

Unlike the bearings of motors and gearheads, the load applied to fan bearings is negligible. Therefore, fan life is determined by deterioration of the grease in the bearings. Since fans have low running and starting torque compared with motors used to drive machinery, they cannot rotate at the proper speed if the grease deteriorates and loses its effectiveness as a lubricant. With severe deterioration, starting voltage increases significantly, and the fan may not start. Deterioration of grease also increases the noise generated by the bearings, further affecting fan life.

Grease life is given by the following expression:

$$\log t = K_1 - K_2 \frac{n}{N\max} - \left(K_3 - K_4 \frac{n}{N\max}\right)T$$

where,
t : Average grease life (h)
K_1, K_2, K_3, K_4 : Constants determined by the grease
$N\max$: Permissible speed of grease lubrication
n : Rotational speed of the bearings
T : Operating temperature of the bearings

As indicated by the above expression, $N\max$ is pre-determined by the ball bearings, so grease life depends on temperature and the rotational speed of the bearings. However, Oriental Motor's products are designed such that the life of the bearings is only minimally affected by their rotational speed. Thus, the average grease life is determined by the temperature since $\frac{n}{N\,max}$ is a constant value.

4. Characteristic Curve for Estimating Product Life

Figure 13 shows the estimated average life characteristics of the **MU1238A** type fan.
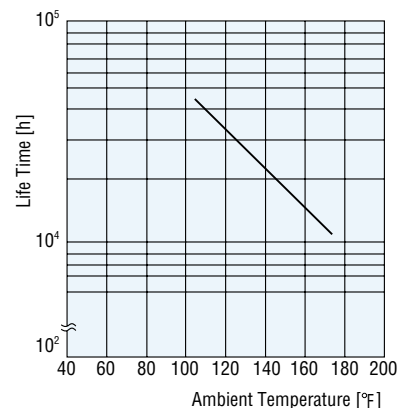

Fig.13 Characteristic curve for estimating life
Note: The values given in this estimated life characteristic curve cannot be guaranteed.

Fig. 13 gives the estimated life of the bearings of the **MU1238A** type fan, obtained by measuring the temperature rise of the ball bearings at the rated voltage and calculating life using the expression for ball bearing grease life.

5. Effect of Speed on fan Life

MD and **MU** fans include not only standard speed models but also middle- and low-speed models. The following is a comparison of service life for three **MD925** models.

Model	Speed	Input (W)	Estimated Life (60°)
MD925A-24	Standard	2.9	34,000 hours
MD925AM-24	Middle	2.2	40,000 hours
MD925AL-24	Low	1.7	45,000 hours

The table indicates that low-speed models with low input have a longer life than standard speed models with high input power. Therefore, where long fan life is required, select a middle- or low-speed model.

■ Overheat protection device

If a fan in run-mode locks due to overload the ambient temperature rises suddenly, the input increases for some reason, the fan temperature rises suddenly. If the fan is left in this state, the performance of the insulation within the fan may deteriorate, shortening service life and in extreme cases scorching the winding and causing a fire. In order to protect the fan from such thermal abnormalities, UL, CSA, EN and IEC standard fans from Oriental Motor are equipped with the following overheating protection devices.

1. Thermal protector

MRS, **MB**, **MF** series contain a built-in automatic return type thermal protector. The construction of the thermal protector is shown in following fig.1.
The **MB840** is protected with impedance protection that prevents the temperature from rising to the temperature at which the thermal protector is triggered even if the fan is locked due to the usage voltage or ambient temperature.
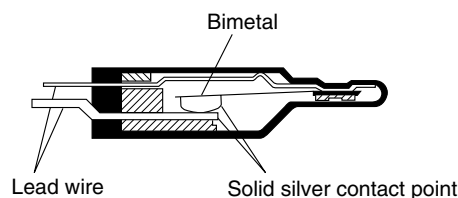

Fig.1 Construction of thermal protector

The thermal protectors employ a bimetal contact, with solid silver used in the contacts. Solid silver has the lowest electrical resistance of all materials and has a thermal conductivity second only to copper.

●Operating temperature of thermal protector

open ⋯⋯⋯⋯⋯120°C±5°C (248°F±9°F)
close ⋯⋯⋯⋯⋯77°C±15°C (170.6°F±27°F)

The fan motor winding temperature, where the thermal protector is working is slightly higher than the operating temperature listed above.

2. Impedance protection

MU, **MB** series (**MB520**, **MB630**) are equipped with impedance protection. Impedance protected motors are designed with higher impedance in the motor windings so that even if the motor locks, the increase in input current is kept down and the temperature does not rise beyond a certain constant level.

3. DC Fan

The DC fan are equipped with overheat protection circuits. When the circuits detect a restraining load, the power switches on and off automatically to control the power flowing through the coil. Consequently, overheating will not occur when a restraining load is applied to the fan blades.