General Application Guidelines

A relay may encounter a variety of ambient conditions during actual use resulting in unexpected failure. Therefore, testing over a practical range under actual operating conditions is necessary. Application considerations should be reviewed and determined for proper use of the relay.

SAFETY PRECAUTIONS

• Use that exceeds the specification ranges such as the coil rating, contact rating and switching life should be absolutely avoided. Doing so may lead to abnormal heating, smoke, and fire.
• Never touch live parts when power is applied to the relay. Doing so may cause electrical shock. When installing, maintaining, or troubleshooting a relay (including connecting parts such as terminals and sockets) be sure that the power is turned off.
• When connecting terminals, please follow the internal connection diagrams in the catalog to ensure that connections are done correctly. Be warned that an incorrect connection may lead to unexpected operation error, abnormal heating, and fire.
• If the possibility exists that faulty adhesion or contact could endanger assets or human life, take double safety precautions and make sure that operation is foolproof.

METHOD OF DETERMINING SPECIFICATIONS

In order to use the relays properly, the characteristics of the selected relay should be well known, and the conditions of use of the relay should be investigated to determine whether they are matched to the environmental conditions, and at the same time, the coil conditions, contact conditions, and the ambient conditions for the relay that is actually used must be sufficiently known in advance. In the table below, a summary has been made of the points of consideration for relay selection. It may be used as a reference for investigation of items and points of caution.

Specification item		Consideration points regarding selection
Coil	a) Rating b) Pick-up voltage (current) c) Drop-out voltage (current) d) Maximum continuous impressed voltage (current) e) Coil resistance f) Temperature rise	1) Select relay with consideration for power source ripple. 2) Give sufficient consideration to ambient temperature and for the coil temperature rise. 3) When used in conjunction with semiconductors, additional attention to the application should be taken. 4) Be careful of voltage drops when starting up.
Contacts	a) Contact arrangement b) Contact rating c) Contact material d) Life e) Contact resistance	1) It is desirable to use a standard product with more than the required number of contacts. 2) It is beneficial to have the relay life balanced with the life of the device it is used in. 3) Is the contact material matched to the type of load? It is necessary to take care particularly with low level usage. 4) The rated life may become reduced when used at high temperatures. Life should be verified in the actual atmosphere used. 5) Depending on the circuit, the relay drive may synchronize with the AC load. As this will cause a drastic shortening of life should be verified with the actual machine.
Operate time	a) Operate time b) Release time c) Bounce time d) Switching frequency	1) Working life verification under actual conditions is required when switching frequency is high because this will shorten life.
Mechanical characteristics	a) Vibration resistance b) Shock resistance c) Ambient temperature d) Life	1) Give consideration to performance under vibration and shock in the use location. 2) In particular, when used in high temperature applications, relay with class B or class F coil insulation may be required.
Other items	a) Breakdown voltage b) Mounting method c) Size d) Protective construction	1) Selection can be made for connection method with plug-in type, printed circuit board type, soldering, and screw fastening type. 2) For use in an adverse atmosphere, sealed construction type should be selected. 3) When used in adverse environments, use the sealed type. 4) Are there any special conditions?

BASICS ON RELAY HANDLING

• To maintain initial performance, care should be taken to avoid dropping or hitting the relay.
• Under normal use, the relay is designed so that the case will not detach. To maintain initial performance, the case should not be removed. Relay characteristics cannot be guaranteed if the case is removed.
• Use of the relay in an atmosphere at standard temperature and humidity with minimal amounts of dust, SO_2, H_2S, or organic gases is recommended.
Also note that use of silicon-based resins near the relay may result in contact failure. For installation in adverse environments, one of the sealed types (sealed type, etc.) should be considered.
• Proper usage requires that the rated voltage be impressed on the coil.
• Be sure the coil impressed voltage does not continuously exceed the maximum allowable voltage.
• The rated switching power and life are given only as guides. The physical phenomena at the contacts and contact life greatly vary depending on the type of load and the operating conditions. Therefore, be sure to carefully check the type of load and operating conditions before use.
• Do not exceed the usable ambient temperature values listed in the catalog.
• Use the flux-resistant type or sealed type if automatic soldering is to be used.
• Use alcohol based cleaning solvents when cleaning is to be performed using a sealed type relay.
• Avoid ultrasonic cleaning of all types of relays.
• Avoid bending terminals, because it may cause malfunction.
• As a guide, use terminal mounting pressure of 40 to 70N {4 to 7kgf} for relays with plug-in terminals.
• For proper use, read the main text for details.

PROBLEM POINTS WITH REGARD TO USE

In the actual use of relays, various ambient conditions are encountered, and because unforeseen events occur which can not be thought of on the drawing board, with regard to such conditions, tests are necessary under the possible range of operation. For example, consideration must always be given to variation of performance when relay characteristics are being reviewed. The relay is a mass production item, and as a matter of principle, it must be recognized that the relay is to be used to the extent of such variations without the need for adjustment.

RELAY COIL

1. Power source for DC input

As a power source for the DC type relay, a battery or either a half wave or full wave rectifier circuit with a smoothing capacitor is used. The characteristics with regard to the excitation voltage of the relay will change depending upon the type of power source, and because of this, in order to display stable characteristics, the most desirable method is perfect DC.

In the case of ripple included in the DC power source, particularly in the case of half wave rectifier circuit with a smoothing capacitor, if the capacity of the capacitor is too small, due to the influence of the ripple, humming develops and an unsatisfactory condition is produced. It is necessary to give consideration to the use of a power source with less than a 5% ripple, with the actual circuit to be used, it is absolutely necessary to confirm the characteristics. (Fig. 1)

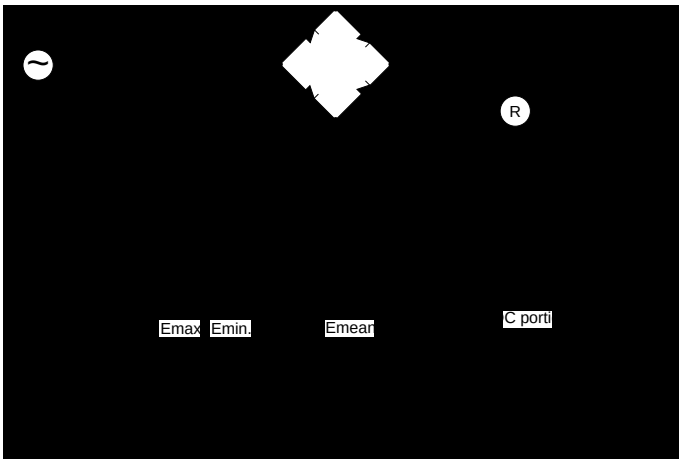


Fig. 1

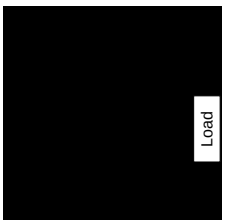
[1] It is desirable to have less than a 5% ripple for the reed type relay (including NR relay also).

[2] For the hinge type relay, a half wave rectifier cannot be used, alone unless you use a smoothing capacitor. The ripple and the characteristics must be evaluated for proper usage.

[3] For the hinge type relay, there are certain applications that may or maynot use the full wave rectifier on it's own. Please check specifications with the original manufacture.

[4] Shown on below, is a circuit driven by the same power supply (battery, etc.) for both the coil and contact.

Coil applied voltage and the drop in voltage. Please verify that the actual voltage is applied to the coil at the actual load. Electrical life will be affected by the drop in voltage in the coil when the load is turned on.



2. Coil temperature rise

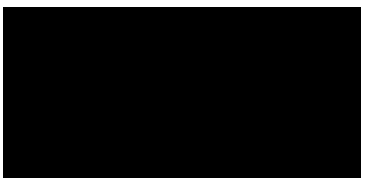
Proper usage requires that the rated voltage be impressed on the coil. Note, however, that if a voltage greater than or equal to the maximum continuous impressed voltage is impressed on the coil, the coil may burn or its layers short due to the temperature rise. Furthermore, do not exceed the usable ambient temperature range listed in the catalog.

• Temperature rise due to pulse voltage

(Please refer to this when PWM control will be used.)

When a pulse voltage with ON time of less than 2 minutes is used, the coil temperature rise bares no relationship to the ON time. This varies with the ratio of ON time to OFF time, and compared with continuous current passage, it is rather small. The various relays are essentially the same in this respect.

Current passage time	%
For continuous passage	Temperature rise value is 100%
ON : OFF = 3 : 1	About 80%
ON : OFF = 1 : 1	About 50%
ON : OFF = 1 : 3	About 35%



• Pick-up voltage change due to coil temperature rise (hot start)

In DC relays, after continuous passage of current in the coil, if the current is turned OFF, then immediately turned ON again, due to the temperature rise in the coil, the pick-up voltage will become somewhat higher. Also, it will be the same as using it in a higher temperature atmosphere. The resistance/temperature relationship for copper wire is about 0.4% for 1°C, and with this ratio the coil resistance increases. That is, in order to cause operation of the relay, the current necessary becomes higher than the pick-up current, accompanying the rise in the resistance value.

General Application Guidelines

3. Operate time

In the case of DC operation, to the extent of large coil input, the operating time is rapid, but if it is too rapid, the “A” contact bounce time is extended.
Please be warned that load conditions (in particular when inrush current is large or load is close to the load rating) may cause the working life to shorten and slight welding.

4. Phase synchronization in AC load switching

If switching of the relay contacts is synchronized with the phase of the AC power, reduced electrical life, welded contacts, or a locking phenomenon (incomplete release) due to contact material transfer may occur. Therefore, check the relay while it is operating in the actual system. However, if problems develop, control the relay using an appropriate phase. (Fig. 2)

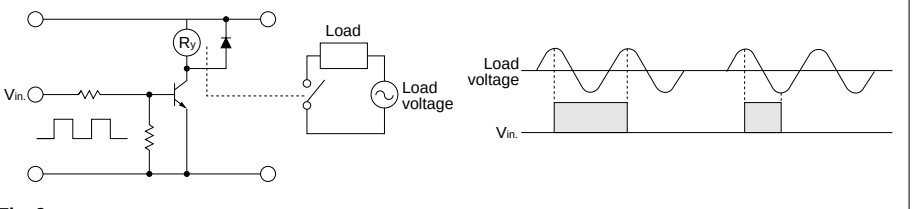


Fig. 2

5. Long term current carrying

In applications which involve lengthy duty cycles, the preferred configuration would be the use of the form B or N.C. contacts for long term duty. In those instances where the form A contact is held closed for extensive time periods, coil heating will increase contact “T” rise and may result in shorter than optimum life. Alternately, latching types may be considered for these applications, using a storage capacitor to “Reset” the relay on power-down.

CONTACT

The contacts are the most important elements of relay construction. Contact performance conspicuously influenced by contact material, and voltage and current values applied to the contacts (in particular, the voltage and current waveforms at the time of application and release), the type of load, frequency of switching, ambient atmosphere, form of contact, contact switching speed, and of bounce.

Because of contact transfer, welding, abnormal wear, increase in contact resistance, and the various other damages which bring about unsuitable operation, the following items require full investigation.

1. Contact circuit voltage, current, and load

[Voltage, AC and DC]

When there is inductance included in the circuit, a rather high counter emf is generated as a contact circuit voltage, and since, to the extent of the value of that voltage, the energy applied to the contacts causes damage with consequent wear of the contacts, and transfer of the contacts, it is necessary to exercise care with regard to control capacity. In the case of DC, there is no zero current point such as there is with AC, and accordingly, once a cathode arc has been generated, because it is difficult to quench that arc, the extended time of the arc is a major cause. In addition, due to the direction of the current being fixed, the phenomenon of contact shift, as noted separately below, occurs in relation to the contact wear. Ordinarily, the approximate control capacity is mentioned in catalogs or similar data sheets, but this alone is not sufficient. With special contact circuits, for the individual case, the maker either estimates from the past experience or makes test on each occasion.

[Current]

The current at both the closing and opening time of the contact circuit exerts important influence. For example, when the load is either a motor or a lamp, to the extent of the inrush current at the time of closing the circuit, wear of the contacts, and the amount of contact transfer increase, and contact welding and contact transfer make contact separation impossible.

2. Characteristics of Common Contact Materials

Characteristics of contact materials are given below. Refer to them when selecting a relay.

Contact Material	Ag (silver)	Electrical conductivity and thermal conductivity are the highest of all metals. Exhibits low contact resistance, is inexpensive and widely used. A disadvantage is it easily develops a sulfide film in a sulfide atmosphere. Care is required at low voltage and low current levels.
	AgCdO (silver-cadmium)	Exhibits the conductivity and low contact resistance of silver as well as excellent resistance to welding. Like silver, it easily develops a sulfide film in a sulfide atmosphere.
	$AgSnO_2$ (silver-tin)	Exhibits superior welding resistance characteristics equal or better than AgCdO. Like silver, it easily develops a sulfide film in a sulfide atmosphere.
	AgW (silver-tungsten)	Hardness and melting point are high, arc resistance is excellent, and it is highly resistant to material transfer. However, high contact pressure is required. Furthermore, contact resistance is relatively high and resistance to corrosion is poor. Also, there are constraints on processing and mounting to contact springs.
	AgNi (silver-nickel)	Equals the electrical conductivity of silver. Excellent arc resistance.
	AgPd (silver-palladium)	At standard temperature, good corrosion resistance and good sulfidation resistance. However, in dry circuits, organic gases adhere and it easily develops a polymer. Gold clad is used to prevent polymer buildup. Expensive.
	PGS alloy (platinum, gold, silver)	Excellent corrosion resistance. Mainly used for low current circuits. (Au : Ag : Pt = 69 : 25 : 6)
Surface Finish	Rh plating (rhodium)	Combines perfect corrosion resistance and hardness. As plated contacts, used for relatively light loads. In an organic gas atmosphere, care is required as polymers may develop. Therefore, it is used in hermetic seal relays (reed relays, etc.) . Expensive.
	Au clad (gold clad)	Au with its excellent corrosion resistance is pressure welded onto a base metal. Special characteristics are uniform thickness and the nonexistence of pinholes. Greatly effective especially for low level loads under relatively adverse atmospheres. Often difficult to implement clad contacts in existing relays due to design and installation.
	Au plating (gold plating)	Similar effect to Au cladding. Depending on the plating process used, supervision is important as there is the possibility of pinholes and cracks. Relatively easy to implement gold plating in existing relays.
	Au flash plating (gold thin-film plating)	Purpose is to protect the contact base metal during storage of the switch or device with built-in switch. However, a certain degree of contact stability can be obtained even when switching loads.

General Application Guidelines

3. Contact Protection

• Counter EMF

When switching inductive loads with a DC relay such as relay sequence circuits, DC motors, DC clutches, and DC solenoids, it is always important to absorb surges (e.g. with a diode) to protect the contacts.

When these inductive loads are switched off, a counter emf of several hundred to several thousand volts develops which can severely damage contacts and greatly shorten life. If the current in these loads is relatively small at around 1A or less, the counter emf will cause the ignition of a glow or arc discharge. The discharge decomposes organic matter contained in the air and causes black deposits (oxides, carbides) to develop on the contacts. This may result in contact failure.

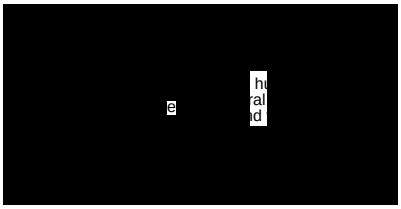


Fig. 1 Example of counter emf and actual measurement on a peak hold meter

In Fig. 1 (a), an emf ($e = -L\frac{di}{dt}$) with a steep waveform is generated across the coil with the polarity shown in Fig. 1 (b) at the instant the inductive load is switched off. The counter emf passes through the power supply line and reaches both contacts.

Generally, the critical dielectric breakdown voltage at standard temperature and pressure in air is about 200 to 300 volts. Therefore, if the counter emf exceeds this, discharge occurs at the contacts to dissipate the energy ($\frac{1}{2}Li^2$) stored in the coil. For this reason, it is desirable to absorb the counter emf so that it is 200V or less.

A memory oscilloscope, digital memory, peak hold meter, etc., can be used to measure the counter emf. However, since the waveform is extremely steep, considerable discrepancies may result depending on the precision of the equipment used. The table shows the counter emf of various relays measured on a high precision peak hold meter.

Actual measurement of counter emf on a peak hold meter

Relay Type \ Nominal Coil Voltage	12V DC
CM relay	Min. 1,600V
CM relay (Resistor inside type)	Approx. 85V

• Material Transfer Phenomenon

Material transfer of contacts occurs when one contact melts or boils and the contact material transfers to the other contact. As the number of switching operations increases, uneven contact surfaces develop such as those shown in Fig. 2. After a while, the uneven contacts lock as if they were welded together. This often occurs in circuits where sparks are produced at the moment the contacts "make" such as when the DC current is large for DC inductive or capacitive loads or when the inrush current is large (several amperes or several tens of amperes).

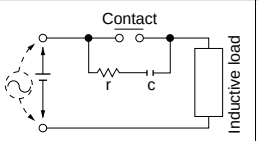
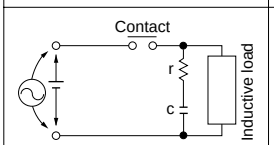
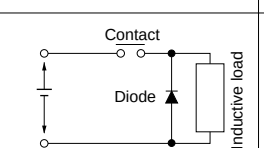
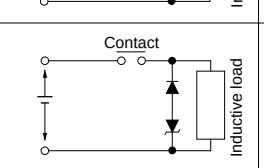
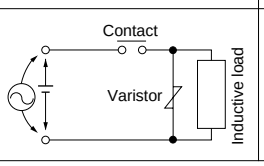
The aim here is to use a contact protection circuit or choose a contact material that is suitable for the load. Generally, a concave formation appears on the cathode and a convex formation appears on the anode. For DC capacitive loads (several amperes to several tens of amperes), it is always necessary to conduct actual confirmation tests.

Fig. 2

• Contact Protection Circuit

Use of contact protective devices or protection circuits can suppress the counter emf to a low level. However, note that incorrect use will result in an adverse effect. Typical contact protection circuits are given in the table below.

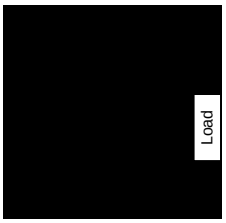
(G: Good, NG: No Good, C: Care)

Circuit		Application AC	Application DC	Features/Others	Devices Selection
CR circuit		C*	G	If the load is a timer, leakage current flows through the CR circuit causing faulty operation. * If used with AC voltage, be sure the impedance of the load is sufficiently smaller than that of the CR circuit	As a guide in selecting r and c, r: 0.5 to 1Ω per 1V contact voltage c: 0.5 to 1µF per 1A contact current Values vary depending on the properties of the load and variations in relay characteristics. Capacitor c acts to suppress the discharge the moment the contacts open. Resistor r acts to limit the current when the power is turned on the next time. Test to confirm. Use a capacitor with a breakdown voltage of 200 to 300V. Use AC type capacitors (non-polarized) for AC circuits.
		G	G	If the load is a relay or solenoid, the release time lengthens. Effective when connected to both contacts if the power supply voltage is 24 or 48V and the voltage across the load is 100 to 200V.	
Diode circuit		NG	G	The diode connected in parallel causes the energy stored in the coil to flow to the coil in the form of current and dissipates it as joule heat at the resistance component of the inductive load. This circuit further delays the release time compared to the CR circuit. (2 to 5 times the release time listed in the catalog)	Use a diode with a reverse breakdown voltage at least 10 times the circuit voltage and a forward current at least as large as the load current. In electronic circuits where the circuit voltages are not so high, a diode can be used with a reverse breakdown voltage of about 2 to 3 times the power supply voltage.
Diode and zener diode circuit		NG	G	Effective when the release time in the diode circuit is too long.	Use a zener diode with a zener voltage about the same as the power supply voltage.
Varistor circuit		G	G	Using the stable voltage characteristics of the varistor, this circuit prevents excessively high voltages from being applied across the contacts. This circuit also slightly delays the release time. Effective when connected to both contacts if the power supply voltage is 24 or 48V and the voltage across the load is 100 to 200V.	—

• Avoid using the protection circuits shown in the figures on the right.
Although DC inductive loads are usually more difficult to switch than resistive loads, use of the proper protection circuit will raise the characteristics to that for resistive loads.

	
Although extremely effective in arc suppression as the contacts open, the contacts are susceptible to welding since energy is stored in C when the contacts open and discharge current flows from C when the contacts close.	Although extremely effective in arc suppression as the contacts open, the contacts are susceptible to welding since charging current flows to C when the contacts close.

• Mounting the Protective Device
In the actual circuit, it is necessary to locate the protective device (diode, resistor, capacitor, varistor, etc.) in the immediate vicinity of the load or contact. If located too far away, the effectiveness of the protective device may diminish. As a guide, the distance should be within 50cm.



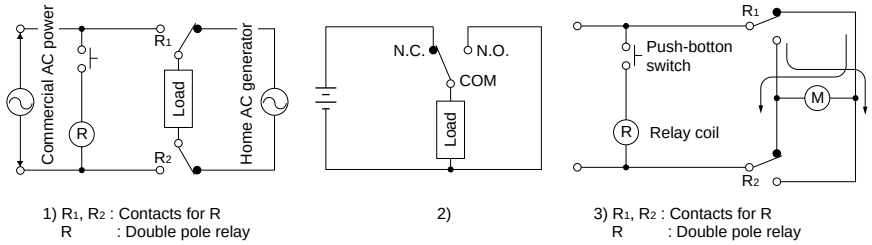
Release time will slow down if, as shown in the diagram, a diode is connected in parallel to the coil in order to absorb relay coil counter electromotive force. Please test under actual load conditions because electrical life will be affected depending on the type of load.

• Abnormal Corrosion During High Frequency Switching of DC Loads (spark generation)
If, for example, a DC valve or clutch is switched at a high frequency, a blue-green corrosion may develop. This occurs from the reaction with nitrogen in the air when sparks (arc discharge) are generated during switching. For relays with a case, the case must be removed or air holes drilled in the case. A similar phenomenon occurs in the presence of ammonia-based gas. Therefore, care is required in circuits where sparks are generated at a high frequency.

4. Cautions on Use Related to Contacts
• Connection of load and contacts
Connect the load to one side of the power supply as shown in Fig. 3 (a). Connect the contacts to the other side. This prevents high voltages from developing between contacts. If contacts are connected to both side of the power supply as shown in Fig. 3 (b), there is a risk of shorting the power supply when relatively close contacts short.

Fig. 3

• Avoid Circuits Where Shorts Occur Between Form A and B Contacts
1) The clearance between form A and B contacts in compact control components is small. The occurrence of shorts due to arcing must be assumed.
2) Even if the three N.C., N.O., and COM contacts are connected so that they short, a circuit must never be designed to allow the possibility of burning or generating an overcurrent.
3) A forward and reverse motor rotation circuit using switching of form A and B contacts must never be designed.



1) R_1, R_2 : Contacts for R
R : Double pole relay

2)

3) R_1, R_2 : Contacts for R
R : Double pole relay

Fig. 4 Bad example of Form A and B use

• Shorts Between Different Electrodes
Although there is a tendency to select miniature control components because of the trend toward miniaturizing electrical control units, care must be taken when selecting the type of relay in circuits where different voltages are applied between electrodes in a multi-pole relay, especially when switching two different power supply circuits. This is not a problem that can be determined from sequence circuit diagrams. The construction of the control component itself must be examined and sufficient margin of safety must be provided especially in creepage between electrodes, space distance, presence of barrier, etc.

General Application Guidelines

• Type of Load and Inrush Current

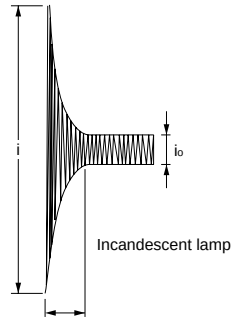
The type of load and its inrush current characteristics, together with the switching frequency, are important factors which cause contact welding. Particularly for loads with inrush currents, measure the steady state and inrush current. Then select a relay which provides an ample margin of safety. The table on the right shows the relationship between typical loads and their inrush currents.

Also, verify the actual polarity used since, depending on the relay, electrical life is affected by the polarity of COM and NO.

Type of load	Inrush current
Resistive load	Steady state current
Solenoid load	10 to 20 times the steady state current
Motor load	5 to 10 times the steady state current
Incandescent lamp load	10 to 15 times the steady state current
Mercury lamp load	Approx. 3 times the steady state current
Sodium vapor lamp load	1 to 3 times the steady state current
Capacitive load	20 to 40 times the steady state current
Transformer load	5 to 15 times the steady state current

Load Inrush Current Wave and Time

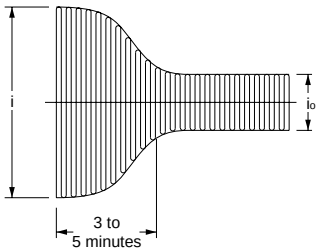
(1) Incandescent Lamp Load



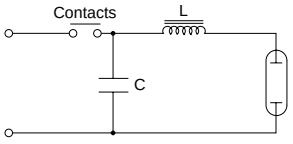
Approx. 1/3 second

Inrush current/rated current
=i/io = 10 to 15 times

(2) Mercury Lamp Load
i/io ≒ 3 times

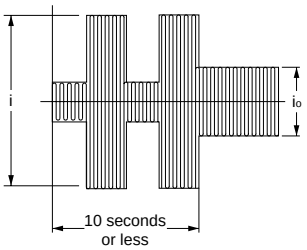


The discharge tube, transformer, choke coil, capacitor, etc., are combined in common discharge lamp circuits. Note that the inrush current may be 20 to 40 times, especially if the power supply impedance is low in the high power factor type.

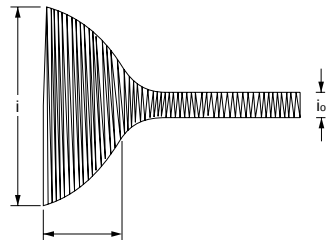


(for high power factor type)

(3) Fluorescent Lamp Load
i/io ≒ 5 to 10 times



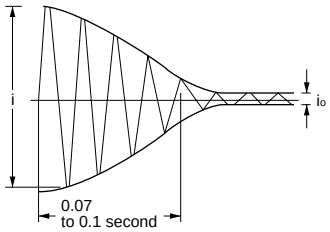
(4) Motor Load i/io ≒ 5 to 10 times



0.2 to 0.5 second

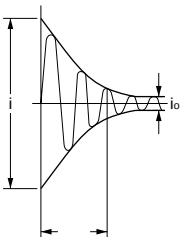
- Conditions become more harsh if plugging or inching is performed since state transitions are repeated.
- When using a relay to control a DC motor and brake, the on time surge current, normal current and off time brake current differ depending on whether the load to the motor is free or locked. In particular, with non-polarized relays, when using from b contact of from contact for the DC motor brake, mechanical life might be affected by the brake current. Therefore, please verify current at the actual load.

(5) Solenoid Load
i/io ≒ 10 to 20 times



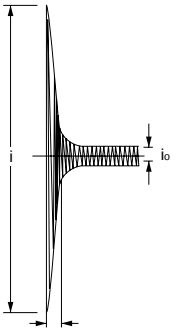
Note that since inductance is great, the arc lasts longer when power is cut. The contact may become easily worn.

(6) Electromagnetic Contact Load
i/io ≒ 3 to 10 times



1 to 2 cycles
(1/60 to 1/30 seconds)

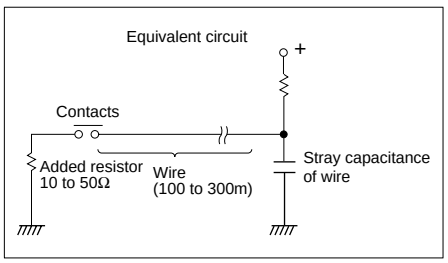
(7) Capacitive Load
i/io ≒ 20 to 40 times



1/2 to 2 cycles (1/120 to 1/30 seconds)

• When Using Long Wires

If long wires (100 to 300m) are to be used in a relay contact circuit, inrush current may become a problem due to the stray capacitance existing between wires. Add a resistor (approx. 10 to 50Ω) in series with the contacts.



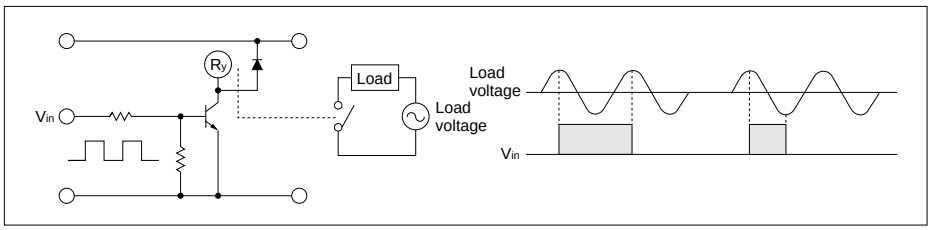
• Electrical life at high temperatures

Verify at the actual load since electrical life may be affected by use at high temperatures.

• If you plan to use in ways other than those shown in the examples in this catalog, please inquire beforehand to a sales office, or verify the usage under actual load conditions.

• Phase Synchronization in Switching AC Loads

If switching of the relay contacts is synchronized with the phase of the AC power, reduced electrical life, welded contacts, or a locking phenomenon (incomplete release) due to contact material transfer may occur. Therefore, check the relay while it is operating in the actual system. However, if problems develop, control the relay using an appropriate phase.



HANDLING CAUTIONS FOR TUBE PACKAGING

Some types of relays are supplied in tube packaging. If you remove any relays from the tube packaging, be sure to slide the stop plug at one end to hold the remaining relays firmly together so they would not move in the tube. Failing to do this may lead to the appearance and/or performance being damaged.

AMBIENT ENVIRONMENT

1. Ambient Temperature and Atmosphere

Be sure the ambient temperature at the installation does not exceed the value listed in the catalog. Furthermore, environmentally sealed types (plastic sealed type) should be considered for applications in an atmosphere with dust, sulfur gases (SO_2, H_2S), or organic gases.

2. Silicon Atmosphere

Silicon-based substances (silicon rubber, silicon oil, silicon-based coating material, silicon caulking compound, etc.) emit volatile silicon gas. Note that when silicon is used near relay, switching the contacts in the presence of its gas causes silicon to adhere to the contacts and may result in contact failure.

In this case, use a substitute that is not silicon-based. Also, although absorption by plastic does occur, it is insignificant in actual practice.

3. Vibration and Shock

If a relay and magnetic switch are mounted next to each other on a single plate, the relay contacts may separate momentarily from the shock produced when the magnetic switch is operated and result in faulty operation.

Countermeasures include mounting them on separate plates, using a rubber sheet to absorb the shock, and changing the direction of the shock to a perpendicular angle.

4. Usage, Storage, and Transport Conditions

1) During usage, storage, or transportation, avoid locations subject to direct sunlight and maintain normal temperature, humidity, and pressure conditions.

The allowable specifications for environments suitable for usage, storage, and transportation are given below.

• Temperature: The allowable temperature range differs for each relay, so refer to the relay's individual specifications.

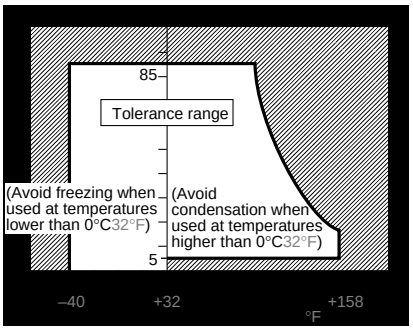
In addition, when transporting or storing relays while they are tube packaged, there are cases when the temperature may differ from the allowable range.

In this situation, be sure to consult the individual specifications.

• Humidity: 5 to 85% R.H.

• Pressure: 86 to 106 kPa

The humidity range varies with the temperature. Use within the range indicated in the graph below.



2) Condensation

Condensation forms when there is a sudden change in temperature under high temperature, high humidity conditions. Condensation will cause deterioration of the relay insulation.

3) Freezing

Condensation or other moisture may freeze on the relay when the temperatures is lower than 0°C 32°F. This causes problems such as sticking of movable parts or operational time lags.

4) Low temperature, low humidity environments

The plastic becomes brittle if the relay is exposed to a low temperature, low humidity environment for long periods of time.

5. Vibration, Impact and Pressure when Shipping

When shipping, if strong vibration, impact or heavy weight is applied to a device in which a relay is installed, functional damage may occur. Therefore, please package in a way, using shock absorbing material, etc., so that the allowable range for vibration and impact is not exceeded.

General Application Guidelines

ENVIRONMENTALLY SEALED TYPE RELAYS

Sealed type relays are available. They are effective when problems arise during PC board mounting (e.g. automatic soldering and cleaning). They also, of course, feature excellent corrosion resistance. Note the cautions below regarding the features and use of environmentally sealed type relays to avoid problems when using them in applications.

1. Operating Environment

Plastic sealed type relays are especially not suited for use in environments which require airtight relays. Although there is no problem if they are used at sea level, avoid atmospheric pressures beyond 96±10kPa. Also avoid using them in an atmosphere containing flammable or explosive gases.

2. Operating Environment of Sealed Type Relays (generation of NOx)

When a plastic sealed type relay is used in an atmosphere high in humidity to switch a load which easily produces an arc, the NOx created by the arc and the water absorbed from outside the relay combine to produce nitric acid. This corrodes the internal metal parts and adversely affects operation.

Avoid use at an ambient humidity of 85%RH or higher (at 20°C 68°F). If use at high humidity is unavoidable, consult us.

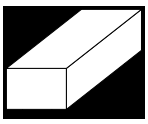
3. Cleaning

When cleaning a printed circuit board after soldering, we recommend using alcohol based cleaning fluids. Please avoid ultrasonic cleaning. The ultrasonic energy from this type of cleaning may cause coil line breakage and light sticking of contacts.

MOUNTING CONSIDERATIONS

1. Top View and Bottom View

Relays used for PC boards, especially the flat type relays, have their top or bottom surface indicated in the terminal wiring diagrams.



Relay with terminals viewed from the bottom (terminals cannot be seen from the top)

2. Mounting Direction

Mounting direction is important for optimum relay characteristics.

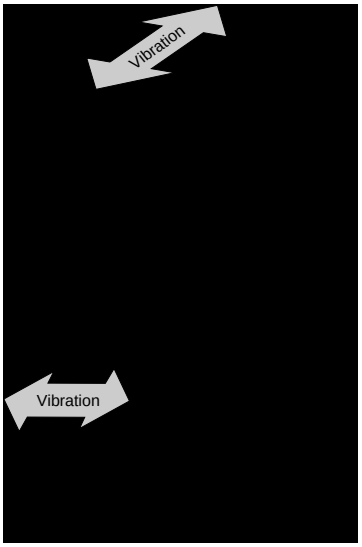
• Shock Resistance

It is ideal to mount the relay so that the movement of the contacts and movable parts is perpendicular to the direction of vibration or shock. Especially note that the vibration and shock resistance of Form B contacts while the coil is not excited is greatly affected by the mounting direction of the relay.

• Contact Reliability

Mounting the relay so the surfaces of its contacts (fixed contacts or movable contacts) are vertical prevents dirt and dust as well as scattered contact material (produced due to large loads from which arcs are generated) and powdered metal from adhering to them.

Furthermore, it is not desirable to switch both a large load and a low level load with a single relay. The scattered contact material produced when switching the large load adheres to the contacts when switching the low level load and may cause contact failure. Therefore, avoid mounting the relay with its low level load contacts located below the large load contacts.



3. Adjacent Mounting

When many relays are mounted close together, abnormally high temperatures may result from the combined heat generated. Mount relays with sufficient spacing between them to prevent heat buildup.

This also applies when a large number of boards mounted with relays are installed as in a card rack. Be sure the ambient temperature of the relay does not exceed the value listed in the catalog.

4. Plug-in Terminals

As a guide, use a connect mounting pressure of 40 to 70N {4 to 7 kgf} for relays with plug-in terminals.

REGARDING CONNECTION OF LEAD WIRES

• When making the connections, depending upon the size of load, the wire cross-section should be at least as large as the values shown in the table.

Permissible current (A)	Cross-section (mm^2)
2	0.2
3	0.3
5	0.5
7.5	0.75
12.5	1.25
15	2
20	2
30	3.5

CAUTIONS FOR USE–Check List

	Check Item
Coil Drive Input	1. Is the correct rated voltage applied? 2. Is the applied coil voltage within the allowable continuous voltage limit? 3. Is the ripple in the coil voltage within the allowable level? 4. For voltage applied to a polarized coil, is polarity observed? 5. When hot start is required, is the increase in coil resistance resulting from coil temperature rise taken into account in setting coil voltage? 6. Is the coil voltage free from momentary drop caused by load current? (Pay special attention for self-holding relays.) 7. Is supply voltage fluctuation taken into account when setting the rated coil voltage? 8. The relay status may become unstable if the coil voltage (current) is gradually increased or decreased. Was the relay tested in a real circuit or with a real load? 9. When driving with transistors, did you consider voltage drops?
Load (Relay contacts)	1. Is the load rated within the contact ratings? 2. Does the load exceed the contacts' minimum switching capacity? 3. Special attention is required for contact welding when the load is a lamp, motor, solenoid, or electromagnetic contractor. Was the relay tested with a real load? 4. A DC load may cause contact lock-up due to large contact transfer. Was the relay tested with a real load? 5. For an inductive load, is a surge absorber used across the contacts? 6. When an inductive load causes heavy arc discharge across the relay contacts, the contacts may be corroded by chemical reaction with nitrogen in the atmosphere. Was the relay tested with a real load? 7. Platinum contacts may generate brown powder due to a catalyzer effect or vibration energy. Was the relay tested with a real load? 8. Is the contact switching frequency below the specification? 9. When there are more than two sets of contacts (2T) in a relay, metallic powder shed from one set of contacts may cause a contact failure on the other set (particularly for light loads). Was the relay tested in a real load? 10. A delay capacitor used across relay contacts may cause contact welding. Was the relay tested with a real load? 11. A high voltage may be induced at transformer load. Was the relay tested with a real load?
Circuit Design	1. Does circuit design take into account electrolytic corrosion of the coil? 2. Are transistors and other circuit components protected from counter electromotive force that develops across the relay coil? 3. Is the circuit designed so the relay coil is left deenergized while the relay is inactive for long period of time? 4. Is the relay operated within the ratings approved by the relevant international standard (if compliance is required)? 5. Is the circuit protected from malfunction when the relay's operation and/or release time varies considerably? 6. Is the circuit protected from malfunctions that might result from relay contact bounce? 7. When there are two or more sets of contacts (2T) in a relay, arc discharges from load switching may cause short circuits across the two or more sets of contacts. Is the circuit designed to suppress such arc discharges? 8. Item 7 above also requires special attention when loads are supplied from separate power sources. 9. Is the circuit protected from malfunction when the relay is to be driven by transistors? 10. When the SCR is used for on/off control, the relay activation tends to synchronize with the line frequency, resulting in an extremely shortened life. Was the relay tested in a real circuit or with a real load? 11. Does the PC board design take into account use of on-board relay?

General Application Guidelines

	Check Item
Operating Environment	1. Is the ambient temperature in the allowable operating temperature range? 2. Is relative humidity below 85 percent? 3. Is the operating atmosphere free from organic and sulfide gases? 4. Is the operating atmosphere free from silicon gas? Depending on the load type, silicon gas may cause a black substance to from on the contacts, leading to contact failure. 5. Is the operating atmosphere free from excessive airborne dust? 6. Is the relay protected from oil and water splashes? 7. Is the relay protected from vibration and impact which may cause poor contact with the socket? 8. Is ambient vibration and impact below the level allowable for the relay? 9. Is the relay free from mechanical resonance after it is installed in position? 10. Is insulation coating applied to the relay along with the PC board? Depending on the load type, a black substance may form to cause contact failure.
Installation and Connection	1. Is the relay protected from solder chips and flux when it is manually soldered? 2. Are preparations for flux application and automatic soldering complete? 3. Is the PC board cleaning process designed to minimize adverse affects to the relays? 4. Are adequate separations provided between polarized or reed relays to prevent magnetic coupling? 5. Are the relay terminals free from stress in the socket? 6. Polarized relay's characteristics may be affected by strong external magnetic field. Are the relays installed away from such fields? 7. If very long leads (100 to 300 meters) are used to connect the load, the stray capacity existing across the leads may cause a surge current. Was the relay tested with a real load? 8. Unless otherwise specified, all relay terminals should be soldered at 250°C 482°F within 5 sec. or at 350°C 662°F within 3 sec. 9. A badly warped PC board can cause stress to the relay terminals which may lead to degraded relay characteristics. 10. Glass shot should not be used to clean the PC board of solder flux. This may cause relay malfunction due to glass powder becoming lodged in the relay's internal structure. 11. Relays should always be used with their plastic shields installed, or degraded relay performance may result. 12. Do not cut away any relay terminal as the stress may cause degraded relay performance.
Storage and Transport	1. Is the relay subject to freezing or condensation (especially when shipping)? 2. Is the temperature in the allowable temperature range? 3. Is the humidity in the allowable humidity range? 4. Is the storing atmosphere free from organic and sulfide gases? 5. Is the storing atmosphere free from excessive airborne dust? 6. Is the relay protected from oil and water splashes? 7. Is the relay subject to the application of heavy weight? 8. When shipping does vibration and impact exceed the allowable range?