

American Zettler, Inc.

**Relay
Technical
Notes**

AMERICAN ZETTLER, INC.

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Technical Notes

INTRODUCTION

The technical notes section is divided into four basic parts: (1) general application guidelines; (2) guidelines for relay handling; (3) guidelines for selecting contact protection circuits; and (4) guidelines for selecting a temperature tolerant relay for your application.

In addition to the Technical Notes section, all data sheets in this catalog also include notes relevant to each specific relay. Please refer to these relay-specific notes, as they contain information vital to optimum relay performance.

If after reading these notes you still have questions on the selection, care, or application of American Zettler relays, please contact our Engineering Department at (949) 831-5000 or send a fax to (949) 831-8642 or E-mail to: sales@azettler.com.

SECTION I: GENERAL APPLICATION GUIDELINES

1. Avoid Abuse

As with any electro-mechanical device, relays are sensitive to abuse. To assure optimum performance, avoid dropping, hitting, or other unnecessary shocks to the relay.

2. Never Remove the Case

The case of a relay is an integral part of that relay. American Zettler relays are not designed to have the case detached. Never remove the case, as specifications or performance cannot be guaranteed.

3. Atmospheric Considerations

American Zettler recommends that you use unsealed relays in an atmosphere with only a minimum of dust and other contaminants. If a relay must withstand a harsh atmosphere, American Zettler recommends that you utilize a sealed relay.

4. Warning—Silicone Based Resins

Some silicone based resins can cause contact failure in a relay. The silicone based resin does not need to

come in direct contact to cause damage—it just needs to be in close proximity. In cases where silicone based resins are used, it is recommended that a sealed relay be used.

5. Polarity

With polarized relays caution must be exercised, as failure to use the correct coil polarity can cause the relay to not operate. Always refer to the wiring diagram in the mechanical specifications for the correct connection.

6. Voltage

To assure meeting the electrical and performance characteristics, only the correct rated voltage should be applied to the coil, i.e., voltage sine waves only for AC coils, rectangular for DC coils.

7. Over-Voltage

Although typically a spike will not effect a relay's performance, the voltage on the coil should not continuously exceed the maximum allowable voltage.

8. Contact Current

Currents that exceed the designated values should be avoided.

9. Check Your Load and Conditions

The specifications provided in this catalog are "typical" specifications and are given only as guidelines. The performance of contacts vary depending on both the type of load and operating conditions encountered. Please consider your specific load and operating conditions in selecting the optimum relay for your application.

10. Warning—Ambient Temperature

The ambient temperature ranges, listed in the general specifications for each relay, must be followed to assure proper operation. Note: Both the storage and operating range differs for the sensitive and standard version of the same model. Refer to the data sheet of the relay for specific information.

11. Ultrasonic Cleaning

Never use any type of ultrasonic cleaning. Ultrasonic cleaning is always traumatic and is not recommended.

12. Relay Operating Temperature

The relay operating temperature varies with ambient temperature, coil power dissipation, and contact dissipation. Ask about AZ's exclusive temperature rise computer program.

13. Pickup and Dropout Voltages

Both pickup and dropout voltages should be considered when selecting a relay coil voltage. For specific information, contact our Engineering Department at 949-831-5000.

14. Power Relays

When using power relays, avoid the use of single diode coil suppression. Use a zener and diode or a capacitor and resistor instead for longer contact life. Also, avoid storing relays in excessively humid conditions as moisture can affect performance in some cases.

SECTION II: GUIDELINES FOR RELAY HANDLING

American Zettler utilizes extensive quality control measures and takes extreme care in packaging to assure that the relays you receive are in the best possible operating condition. Once they enter your facility, some common sense care can prevent damage during handling. Some areas to closely monitor and supervise include:

1. Handling

• *Avoid handling relay terminals.*

Oils and contaminants common to the human hand can cause contamination of the surface finish which in turn can lead to solderability problems.

• *Always store relays at recommended temperatures.*

Observe maximum storage temperatures listed in the general specifications section of the data sheet for your specific relay.

• *Avoid misalignment of the terminal layout and P.C. board hole pattern.*

Even if there is just a slight misalignment, forcing a relay into the board can cause relay damage compromising such important factors as seal integrity, relay performance, and relay reliability.

• *Always store and handle relays in a clean environment.*

Your relays are state-of-the-art, electromechanical components and should be stored and handled as such. Even environmentally sealed relays have exposed terminals that are subject to contamination and therefore are minimally sensitive to their storage and production environment.

2. Mounting

• *Suggested PC board layout.*

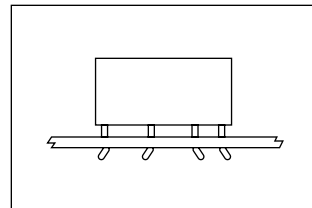
Refer to the PC board layout located on the data sheet for your specific relay.

• *For automatic insertion.*

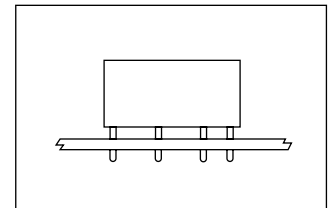
American Zettler relays are available packaged for a variety of automatic insertion machines. Please consult our Sales Department.

• *Never bend terminals.*

Once relay terminals are bent performance can no longer be guaranteed. Never bend terminals to make them self-clinching and avoid bending them to fit misaligned holes.



Incorrect. Bending the relay leads, for any reason, can cause failure.



Correct. Relay terminals remain straight, and penetrate completely through the PC board.

3. Flux Application

• *Examine your procedure.*

To assure minimum production trauma, thoroughly examine the fluxing procedure for the specific relay you are using. If the relay you have selected is not sealed, be particularly careful as unsealed relays are

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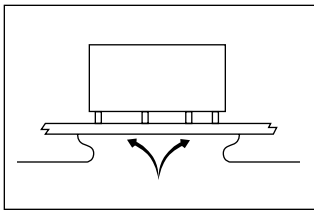
more susceptible to internal flux contamination, resulting in compromised performance and reliability.

- **Use rosin-based non-corrosive flux.**

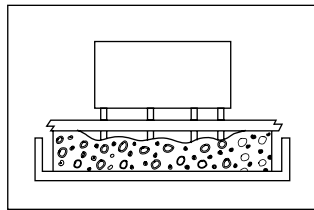
This type of flux has been extensively tested and is the least hostile to the materials common to relays. If another type of flux is required or preferred, please consult with our Engineering Department at to determine compatibility.

- **Don't overflow the board.**

Adjust the PC board's position so that the flux doesn't overflow the top of the board. This is especially critical for unsealed relays as they are susceptible to contamination due to overflow flux (see diagram).



Correct. Solder flux circulates freely under the PC board, does not overflow.



Incorrect. Flux sponge method promotes flux contamination.

- **Avoid flux sponge method.**

Utilizing a flux sponge is not recommended. Often the downward pressure exerted on the relay and sponge is enough to force the flux into unsealed relays causing compromised integrity.

4. Preheating

- **Always preheat.**

Where possible, American Zettler recommends that you always preheat relays prior to fluxing and soldering, as preheating promotes better soldering. For unsealed relays preheating also helps prevent the penetration of flux into the relay during fluxing and soldering.

- **Recommended temperature and time.**

Recommended temperature and time for preheat is 100°C (212°F) or less for a duration of approximately 1 minute.

- **Don't overheat.**

Do not expose relays to high temperatures for long periods of time as it may affect relay characteristics. If you are in doubt about your specific procedure, please contact our Engineering Department.

5. Automatic Soldering

- **Review Process.**

Like fluxing, automatic soldering can be traumatic to an unsealed relay. Always thoroughly review your soldering procedure in light of the relay you are utilizing, and check the thermal profile of the process with American Zettler's Engineering Department.

- **Optimum method.**

The recommended method for automatic soldering is flow soldering. Always adjust the level of solder so that it does not overflow the printed circuit board.

- **Suggested automatic soldering temperature.**

Unless otherwise specified, a solder temperature of 270°C (518°F) is recommended.

- **Suggested automatic soldering time.**

Unless otherwise specified, a time period of approximately 5 seconds is recommended.

6. Hand Soldering

- **Soldering iron care.**

Always keep the tip of your soldering iron clean as contaminants on the iron can easily be transferred to the solder and inhibit conductivity.

- **Suggested hand soldering iron wattage.**

Suggested wattage range for your relay soldering iron is 30–60W.

- **Suggested hand soldering temperature.**

Unless otherwise specified, the suggested soldering temperature is approximately 300°C (572°F).

- **Suggested hand soldering duration.**

Unless otherwise specified, the suggested soldering duration should be approximately 3 seconds.

7. Relay Cooling

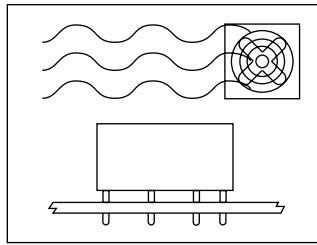
- **Air cooling.**

Prompt air cooling is recommended as it prevents deterioration of the relay due to soldering heat.

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• **Cold liquids.**

Although it is safe to totally immerse an environmentally sealed relay, it is better to avoid immersing a relay into cold liquids immediately after soldering.



Cooling method of choice is air cooling.

8. Cleaning

• **Sealed relays.**

Sealed relays can be safely cleaned by immersion. Select a suitable solvent by referring to the cleaning solvent compatibility chart. If you are considering a solvent not mentioned in this chart, contact our Engineering Department for more information.

	Fluorinated	Aqueous	Chlorinated	Alcoholic
Solvent	Freon TF	Aqua Flux	Perclean B-5	IPA
Trade	Freon TE	#WL 1000	Perclean D	Ethanol
Names	Freon TES	Indusco 624	Cholorothene VG	
	Freon TMC	Indusco 1000	Cholorothene N	
	Alpha 1001	Lonco Terge 530	Chlorosolve	
	Alpha 1003	Hollis 310	Alpha 564	
			Trichloroethan	

• **Avoid ultrasonic cleaning.**

Ultrasonic cleaning on relays may cause problems such as breaks in the coil or slight sticking of the contacts.

• **Unsealed relays.**

Never clean unsealed relays by immersion.

• **Relays with a removable tab.**

Relays with a removable tab should be vented (if desired) after cooling to room temperature following cleaning and drying.

9. Coating

• **Unsealed relays.**

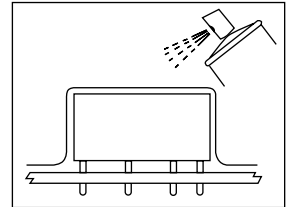
Never coat dust-cover or just flux resistant relays. Coating can penetrate the relay and in some cases cause contact failure. If board coating is required, mount the relay after coating.

• **Flexibility.**

Carefully check the flexibility specifications of the coating material you are planning to utilize because a coating that lacks the proper flexibility may peel off from thermal stress.

• **Coating selection.**

Some coating materials may have an adverse affect on certain types of relays. Select coating materials carefully and check the Coating/Relay Suitability chart.



Coating/Relay Suitability

Coating Type	Materials Compatibility	Advantages/ Disadvantages
Epoxy Based	Best	<ul style="list-style-type: none"> • Good electrical insulation • Does not affect contacts • Harder to apply
Urethane Based	Fair	<ul style="list-style-type: none"> • Easy to apply • Good electrical insulation • Possible solvent damage to case (check prior to use)
Silicone Based	Least	<ul style="list-style-type: none"> • Good electrical insulation • Easy to apply • Not suitable for unsealed relays—gas may cause failure

SECTION III: GUIDELINES FOR SELECTING CONTACT PROTECTION CIRCUITS

Proper selection is critical as the use of a contact protection device can extend contact life. When mounting the protection device, always locate it near the immediate area of the load or contact. Typically you should mount a protective device within 18 inches of the load or contact.

Typical contact protection circuits are provided for an overview but the circuit you are planning to utilize should be thoroughly examined. For more specific information on any of these circuits, contact our Engineering Department.

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DIODE AND ZENER DIODE CIRCUIT

Diagram	Notes
	<ul style="list-style-type: none"> • DC applications only • Utilize when diode circuit causes too long release time • Use zener diode with zener voltage about equal to power supply voltage

DIODE CIRCUIT

Diagram	Notes
	<ul style="list-style-type: none"> • DC applications only • Compared to RC type, circuit delays release time (2 to 5 times values stated in catalog). • For larger voltages, use diode with reverse breakdown 10 times circuit voltage and forward load circuit. • For smaller voltages, use reverse breakdown V of 2 to 3 times power supply voltage.

CR CIRCUITS

Diagram	Notes
	<ul style="list-style-type: none"> • Circuit A is suitable for AC or DC applications, but if used with AC voltage, impedance of the load should be smaller than the CR circuit's. Do not utilize for timer loads, as leakage current can cause faulty operations.
	<ul style="list-style-type: none"> • Circuit B is suitable for AC or DC. If the load is a relay or solenoid, release times lengthen. Effective when connected to both contacts, power supply voltage across the load is 100 to 200 V.

VARISTOR CIRCUIT

Diagram	Notes
	<ul style="list-style-type: none"> • Effective for AC and DC applications • Circuit slightly delays release time. Effective when connected to both contacts, power supply voltage across the load is 100 to 200 V.

• In-Rush Current.

The type of load and its in-rush current characteristics, together with switching frequency, can cause contact welding. For loads with in-rush current, measure the steady state current and in-rush current to determine the proper relay. Some typical types of

loads and the in-rush current they create are summarized in the following chart:

Type of Load	In-rush 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	Approximately 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

SECTION IV: GUIDELINES FOR SELECTING A TEMPERATURE TOLERANT RELAY

More and more applications require relays that operate at higher temperatures. Relays run "hot" due to high ambient temperatures and/or high contact switching current. These "hotter" environments can destroy a relay's insulation system and lead to product failure in the field.

To help prevent this type of failure, American Zettler has for several years, offered as a standard feature, UL Class B (130°C) insulating systems on its miniature power relays. These Class B relays have a significant "heat" advantage over Class A relays that, by contrast, only offer a rating of 105°C. Recently, American Zettler also introduced a new insulation system for its AZ8 and AZ2100 high current relays. This new system is designated by UL as Class F and it is rated at a full 155°C. This section outlines the reasons why an engineer should select a high temperature rated relay for his/her application.

First, let's define an insulation system as it pertains to this application note. An insulation system may be defined as simply any combination of insulating materials used in electrical equipment. In a relay it is the combination of a coil form, the magnet wire coating, and the outer wrapping of the relay coil.

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A proper insulating system is essential because it separates the control side of a relay (the coil) from the switching side of the relay (the contacts). The switch side of the relay may be used to switch high voltages that are potentially lethal to both humans and the circuitry that is connected to the coil side of the relay.

Consequently, when a relay is evaluated for a particular project it should be evaluated at the maximum ambient temperature it will see in that product. If the insulating system breaks down, it allows electrical current to flow from the switch side of the relay to the control side of the relay. This in turn causes failure and in some cases can present a safety hazard.

UL understands that time and temperature are the enemies of an insulating system. Just as paint on a house begins to peel with age and exposure to heat, an insulating system begins to break down with age and exposure to heat. Consequently, UL designed and administers a series of tests that assure that this breakdown does not occur even after aging and heating.

UL Document 1446 is concerned with systems of insulating materials. Insulating systems are classified by their ability to withstand elevated temperatures. It is from this document that we derive Class A, Class B, and Class F.

Table 3.1

Maximum Hot Spot Temperatures of Insulating Systems		
System Class	Max. Hot Spot Temp.	
	°C	°F
130 (B)	130	(266)
155 (F)	155	(311)
180 (H)	180	(356)
200 (N)	200	(392)
220 (R)	220	(428)
240 (S)	240	(464)
Over 240 (C)	Over 240	Over (464)

Table 3.1 is printed directly from the UL document. As it indicates, a Class B relay is rated for a maximum hot spot temperature of 130°C, and Class F relay is

rated for a maximum hot spot temperature of 155°C. For a relay, the hot spot temperature is basically the coil temperature. The coil temperature is a result of the self-heating of the coil due to the power dissipation of the coil (coil voltage and current), heating due to the load being carried by the contacts (they get hot too and that leaks over to the coil), and by the ambient temperature of the environment.

At room temperature, most relay coils will not exceed a temperature of 130°C even with full contact load and continuous operation. However, if a particular circuit design calls for the relay to work in a high ambient temperature, or at a coil voltage higher than nominal (or both), it is possible that the coil temperature might exceed 130°C. Sometimes the designer does not realize this until the product gets to UL and at that point it is determined that a higher class of insulating system is required. If the Class B (rated up to 130°C) is not sufficient, Class F (rated up to 155°C) would be the next logical choice. Class F relays are proving to be ideal for applications such as:

- Appliance Controls
- Automotive Controls
- Spa and Pool Controls
- Industrial controls

Plus, as power relays are used more and more in control applications, and boards get smaller and smaller allowing less room for heat dissipation, Class B and Class F relays become increasingly attractive.

To help circuit designers estimate the final coil temperatures of a relay when all factors are considered, the American Zettler Technical Services Department has developed an industry-unique computer program. This program runs on an IBM PC or a clone under Microsoft Excel. **Please call our Sales Department for details on how to get this program free of charge.**

Technical Definitions

ADJUSTMENT. The modification of any or all of the elements of tension shape or position of relay parts (to affect one or more of the operating characteristics or to meet mechanical requirements), for example, adjustments of armature gap, restoring spring force, contact gap, or contact force.

AMPERE-TURNS. The product of the number of turns in an electromagnetic coil winding and the current in amperes passing through the winding. With AC the RMS current value is generally used in the product of current and turns and is referred to as RMS ampere-turns.

ARMATURE. The moving magnetic member of an electromagnetic relay structure.

BIAS, MAGNETIC. A steady magnetic field (permanent magnet) applied to the magnetic circuit of a relay to aid or impede operation of the armature.

BOBBIN. A structure upon which a coil is wound.

BOUNCE, CONTACT. Internally caused intermittent and undesired opening of closed contacts or closing of open contacts of a relay, caused by one or more of the following:

- (1) Impingement of mating contacts.
- (2) Impact of the armature against the coil core on pickup or against the backstop on dropout.
- (3) From momentary hesitation, or reversal of the armature motion during the pickup or dropout stroke.

BREAK. The opening of closed contacts to interrupt an electric circuit.

BRIDGING. (1) Normal bridging: the normal make-before-break action of a make-break or "D" contact combination. In a stepping switch the coming together momentarily of two adjacent contacts, by a wiper shaped for that purpose, in the process of moving from one contact to the next. (2) Abnormal bridging: the undesired closing of open contacts caused by metallic bridge or protrusion developed by arcing.

COIL. An assembly consisting of one or more windings, usually wound over an insulated iron core or on a bobbin or spool, or self-supporting, with terminals, and other required parts such as a sleeve or slug.

CONTACT. (1) The portion of current-carrying members at which electric circuits are opened or closed. (2) The current carrying part of a relay that engages or disengages to open or close electric circuits. (3) Used to denote a combination or set. ("Contacts" also used).

CONTACT, ARMATURE. (1) A contact mounted directly on the armature. (2) Sometimes used for a movable contact

CONTACT GAP. The gap between the contact tips (points), under specified conditions, when the contact circuit is open.

CONTACT FORCE. The force which two contact tips (points) exert against each other in the closed position under specified conditions.

CONTACT FOLLOW. The further specified movement of the contact tips (points) when making and after they have just touched and while they are travelling in the same direction as that of the moving contact member.

CONTACT WIPE. When a contact is making, the relative rubbing movement of contact tips (points) after they have just touched.

CONTACT, BIFURCATED. A forked, or branched, contacting member so formed or arranged as to provide some degree of independent dual contacting.

CONTACT, DRY CIRCUIT. A contact that carries current but neither opens nor closes while its load circuit is energized. Erroneously used if referring to low level contacts.

CONTACT, LOW LEVEL. Contacts that control only the flow of relatively small currents in relatively low-voltage circuits; for example, alternating currents and voltages encountered in voice or tone circuits, direct currents in the order of microamperes, and voltage below the softening voltages of record for various contact materials (that is 0.080 volt for gold, 0.25 volt for platinum, etc.). Also defined as contact switching loads where there is no electrical (arc transfer) or detectable thermal effect and where only mechanical forces can change the conditions of the contact interface.

CONTACT, MOVABLE. The member of a contact combination that is moved directly by the actuating system. This member is also referred to as the armature contact or swinger contact.

CONTACT, NORMALLY CLOSED. A contact combination which is closed when the armature is in its unoperated position. Contact, normally open. A contact combination that is open when the armature is in its unoperated position.

CONTACT, STATIONARY. A member of a contact combination that is not moved directly by the actuating system.

CONTACT WELD. A contacting failure due to fusing of contacting surfaces to the extent that the contacts fail to separate when intended to do so.

CONTACTOR. See relay, power.

DIELECTRIC STRENGTH. The maximum allowable AC RMS voltage (50/60 Hz) which may be applied between two specified test points.

DROPOUT, TO DROP OUT. A monostable relay drops out when it changes from an energized condition to the unenergized condition.

ENERGIZATION. The application of power to a coil winding of a relay. With respect to an operating coil winding use of the word commonly assumes enough power to operate the relay fully, unless otherwise stated.

FRAME. The main supporting portion of a relay, which may include parts of the magnetic structure.

GAP, ARMATURE. The distance between armature and pole face.

GAP, CONTACT. The distance between a pair of mating relay contacts when the contacts are open.

INSULATION RESISTANCE. The DC resistance between input and output of solid state relays and across contact and between contacts and coil for electromechanical and reed relays.

LOAD, CONTACT. The electrical power encountered by a contact set in any particular application.

MAKE. The closure of open contacts to complete an electric circuit.

MECHANICAL SHOCK NON-OPERATING. That mechanical shock level (amplitude, duration and wave shape) to which the relay may be subjected without permanent electrical or mechanical damage.

MECHANICAL SHOCK, OPERATING. That mechanical shock level (amplitude, duration, and wave shape) to which the relay may be subjected without electrical malfunction or mechanical damage.

OPERATING CHARACTERISTICS. Pickup, nonpickup, hold and dropout, voltage or current.

DROPOUT VALUE, MEASURED. As the current or voltage on an operated relay is decreased, the value at which all contacts restore to their unoperated positions.

DROPOUT VALUE, SPECIFIED. As the current or voltage on an operated relay is decreased, the value at or above which all relay contacts must restore to their unoperated positions.

HOLD VALUE, SPECIFIED. As the current or voltage on an operated relay is decreased, the value which must be reached before any contact change occurs.

NONPICKUP VALUE, SPECIFIED. As the current or voltage on an unoperated relay is increased, the value which must be reached before any contact change occurs.

PICKUP VALUE, MEASURED. As the current or voltage on an unoperated relay is increased, the value at which all contacts function.

PICKUP VALUE, SPECIFIED. As the current or voltage on an unoperated relay is increased, the value at or below which all contacts must function.

OVERTRAVEL, ARMATURE DROPOUT. The portion of the armature travel that occurs between closure of the normally closed contact(s) and the fully released static position of the armature.

OVERTRAVEL, ARMATURE PICKUP. The portion of the armature travel occurring between closure of the normally open contact(s) and the fully operated static position of the armature.

PICKUP, TO PICK UP. A monostable relay picks up when it changes from the unenergized condition to an energized condition.

POLE, DOUBLE. A term applied to a contact arrangement to denote that it includes two separate contact combinations, that is, two single-pole contact assemblies.

RATING, CONTACT. The electrical load handling capability of relay contacts under specified conditions and for a prescribed number of operations.

RELAY. An electrically controlled device that opens and closes electrical contacts to effect the operation of other devices in the same or another electrical circuit.

RELAY, ENCLOSED.

- (1) **HERMETICALLY SEALED** A relay contained within an enclosure that is sealed by fusion or other comparable means to ensure a low rate of gas leakage. (Generally metal-to-metal or metal-to-glass sealing is employed.)
- (2) **ENCAPSULATED** A relay embedded in a suitable potting compound
- (3) **SEALED** A relay that has both coil and contacts enclosed in a relatively airtight cover
- (4) **COVERED** A relay contained in an unsealed housing. Note—The coil and contact assemblies may be separately enclosed and isolated from each other by various combinations of the above enclosures.

RELAY, LATCHING. A relay that maintains its contacts in the last position assumed without the need of maintaining coil energization.

- (1) **MAGNETIC LATCHING.** A relay that remains operated, held by either remnant magnetism in the structure or by the influence of a permanent magnet, until reset. (See also relay, polarized bistable.)

RELAY, POLARIZED. A relay whose operation is dependent upon the polarity of the energizing current.

RELAY, BISTABLE A bistable polarized relay is a 2-position relay that will remain in its last operated position keeping the operated contacts closed after the operating winding is de-energized.

RELAY, POWER. A relay with heavy-duty contacts usually rated 15 amperes or higher. Sometimes called a contactor.

RELAY, REED. A relay using glass-enclosed magnetic reeds as the contact members.

RELAY, SENSITIVE. A relay that operates on comparatively low input power.

RESET. The return of contacts or a mechanism to the normal state.

RESISTANCE, CONTACT. The electrical resistance of closed contacts as measured at their associated contact terminals.

SENSITIVITY. Specified pickup expressed in watts.

TIME, CONTACT BOUNCE. The time interval from initial actuation of a contact to the end of bounce.

TIME, OPERATE. The time interval from coil energization to the functioning of the last contact to function. Where not otherwise stated, the functioning time of the contact in question is taken as its initial actuation time (that is, it does not include contact bounce time).

TIME, RELEASE. The time interval from coil de-energization to the functioning of the last contact to function. Where not otherwise stated, the functioning time of the contact in question is taken as its initial actuation time (that is, it does not include contact bounce time).

WIPE, CONTACT. The sliding or tangential motion between two mating contact surfaces as they open or close.