

# Enclosed Switch

# ZC-□55

## Small, High-precision Enclosed Switch



- Small, High-precision Enclosed Switches with Built-in Basic Switches for High Repeatability and Durability of 10 Million Operations Minimum.
- Same mounting pitch as Z Basic Switch.
- Requires less operating force than conventional limit switches.
- Lineup includes modes with operation indicators for easy maintenance and inspection.
- Approved by EN, UL, CSA, and CCC (Chinese standard). (Ask your OMRON representative for Information on approved models.)



Be sure to read *Safety Precautions* on page 7 and *Safety Precautions for All Limit Switches*.

## Model Number Structure

### Model Number Legend

ZC-□55  
(1)

#### (1) Actuator

- D: Plunger
- Q: Panel mount plunger
- Q22: Panel mount roller plunger
- Q21: Panel mount crossroller plunger
- N22: Sealed roller plunger
- N21: Sealed crossroller plunger

- W: Short hinge lever
- W1: Hinge lever
- W2: Short hinge roller lever
- W21: Hinge roller lever
- W3: One-way action short hinge roller lever
- W31: One-way action hinge roller lever

## Ordering Information

Actuator	Model	Approved Standards		
		UL	CSA	EN
Plunger	ZC-D55	●	●	●
Panel mount plunger	ZC-Q55	●	●	●
Panel mount roller plunger	ZC-Q2255	●	●	●
Panel mount crossroller plunger	ZC-Q2155	●	●	●
Sealed roller plunger	ZC-N2255	●	●	●
Sealed crossroller plunger	ZC-N2155	●	●	●
Short hinge lever	ZC-W55	●	●	●
Hinge lever	ZC-W155	●	●	●
Short hinge roller lever	ZC-W255	●	●	●
Hinge roller lever	ZC-W2155	●	●	●
One-way action short hinge roller lever	ZC-W355	●	●	●
One-way action hinge roller lever	ZC-W3155	●	●	●

- Note: 1. Use molded terminal models when using the Switch under one of the following conditions:  
a) dusty, b) high amount of dripping oil, or c) high humidity.  
2. Models are available with lead outlets in three positions: right-hand, left-hand, and underside.

## Specifications

### Approved Standards

Agency	Standard	File No.
UL*	UL508	E76675
TÜV Rheinland	EN60947-1, EN60947-5-1	J50041904
CCC(CQC)	GB14048.5	2003010303077620

Note: Ask your OMRON representative for information on approved models.  
 \* UL certified for CSA C22.2 No. 14.

### Ratings

Rated voltage	Non-inductive load (A)				Inductive load (A)			
	Resistive load		Lamp load		Inductive load		Motor load	
	NC	NO	NC	NO	NC	NO	NC	NO
125 VAC	10		3	1.5	10		5	2.5
250 VAC	10		2.5	1.25	10		3	1.5
8 VDC	10		3	1.5	6		5	2.5
14 VDC	10		3	1.5	6		5	2.5
30 VDC	6		3	1.5	5		5	2.5
125 VDC	0.5		0.4	0.4	0.05		0.05	0.05
250 VDC	0.25		0.2	0.2	0.03		0.03	0.03

Inrush current	NC	30 A max.
	NO	15 A max.

- Note: 1. The above figures are for steady-state currents.  
 2. Inductive loads have a power factor of 0.4 min. (AC) and a time constant of 7 ms max. (DC).  
 3. Lamp load has an inrush current of 10 times the steady-state current.  
 4. Motor load has an inrush current of 6 times the steady-state current.  
 5. The above ratings were tested under the following conditions according.  
 (1) Ambient temperature: +20±2°C  
 (2) Ambient humidity: 65±5%RH  
 (3) Operating frequency: 20 operations/min.

### Characteristics

Degree of protections	IP67	
Durability	Mechanical	10,000,000 operations min.
	Electrical	500,000 operations min.
Operating speed	0.05 mm/s to 0.5 m/s *1	
Operating frequency	Mechanical	120 operations/min
	Electrical	20 operations/min
Insulation resistance	100 MΩ min. (at 500 VDC)	
Contact resistance	15 mΩ max. (initial value)	
Dielectric strength	Between non-continuous terminals	1,000 VAC, 50/60 Hz for 1 min
	Between each terminal and non-current-carrying metal parts	2,000 VAC, 50/60 Hz for 1 min
Rated insulation voltage (Ui)	1,000 VAC	
Pollution degree (operating environment)	3 (IEC947-5-1)	
Short-circuit protective device	10 A-fuse type gG (IEC 60269)	
Protection against electric shock	Class II	
Proof tracking index (PTI)	175	
Switch category	D (IEC335)	
Rated operating current (Ie)	10 A	
Rated operating voltage (Ue)	250 VAC	
Vibration resistance	Malfunction	10 to 55 Hz, 1.5-mm double amplitude *2
	Destruction	1,000 m/s <sup>2</sup> max.
Shock resistance	Malfunction	300 m/s <sup>2</sup> max. (in case of plunger model) *1 *2
	Destruction	1,000 m/s <sup>2</sup> max.
Ambient operating temperature	-10°C to +80°C (with no icing)	
Ambient operating humidity	35% to 95%RH	
Weight	Approx. 92 g (in case of ZC-Q22(21)55)	

\*1. Only for models with plungers. (Contact your OMRON representative for information on other models.)  
 \*2. Less than 1 ms under a free state at the operating limits.

### Approved Standard Ratings UL/CSA

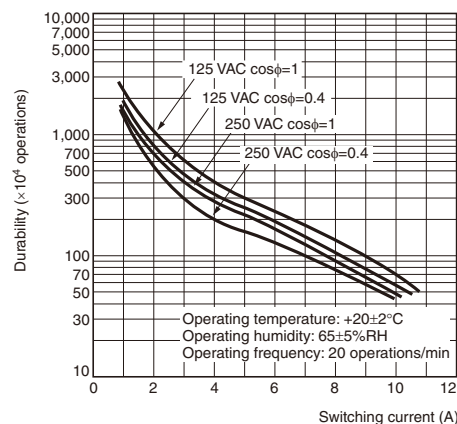
#### A300

Voltage	Carry current	Current (A)		Volt-amperes (VA)	
		Make	Break	Make	Break
120 VAC	10A	60	6	7,200	720
240 VAC		30	3		

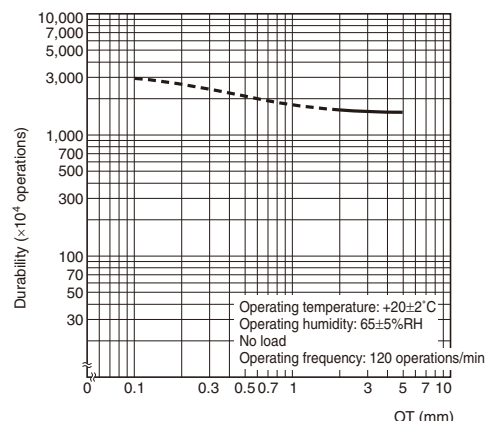
TÜVRheinland (EN60947-1, EN60947-5-1),  
 CCC (GB14048.5)

Applicable category and ratings
AC-12 10 A/250 VAC

### Engineering Data Electrical Durability



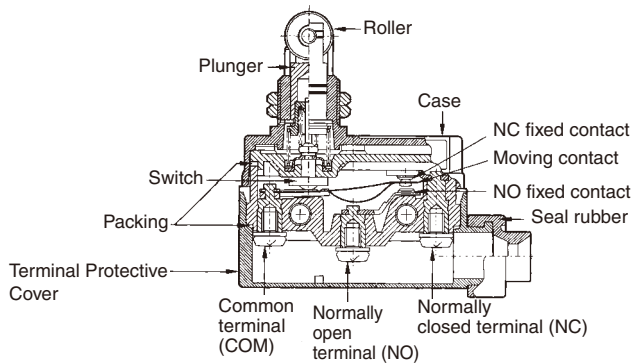
### Mechanical Durability (for ZC-Q55)



## Structure and Nomenclature

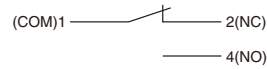
### Structure

Changing the Terminal Protective Cover around allows the cable to be pulled out from either the right or the left.



Note: M4 binding head screws (with toothed washers) are used as the terminal screws.

### Contact Form

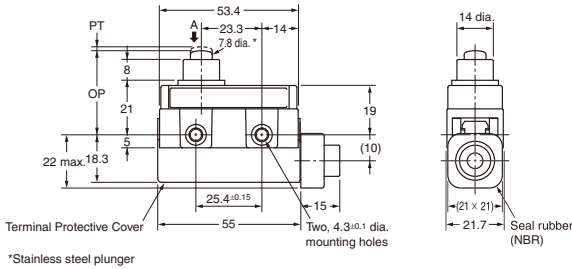


## Dimensions and Operating Characteristics

(Unit: mm)

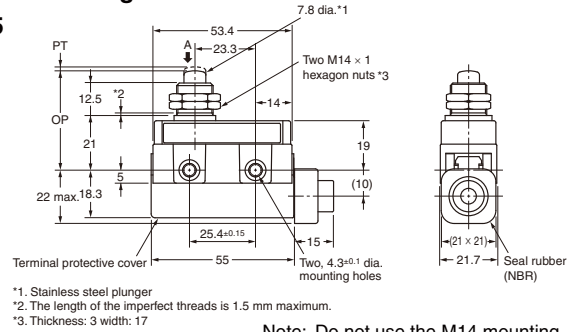
### Plunger

#### ZC-D55



### Panel Mount Plunger

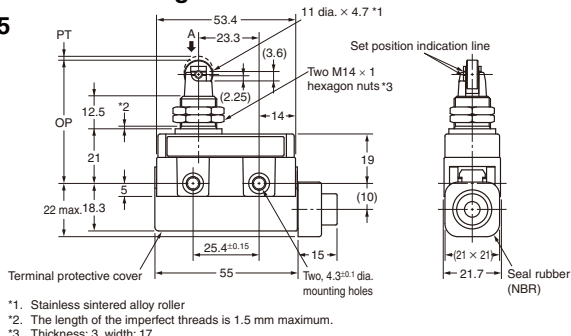
#### ZC-Q55



Note: Do not use the M14 mounting screw and the case mounting hole at the same time.

### Panel Mount Roller Plunger

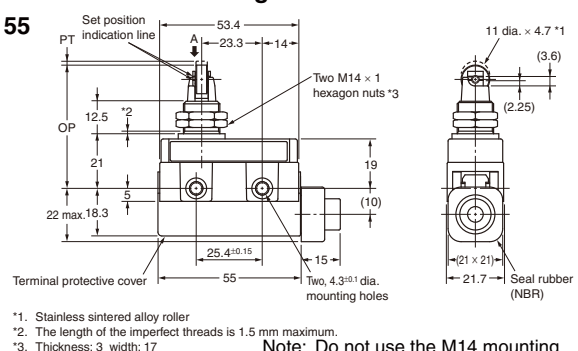
#### ZC-Q2255



Note: Do not use the M14 mounting screw and the case mounting hole at the same time.

### Panel Mount Crossroller Plunger

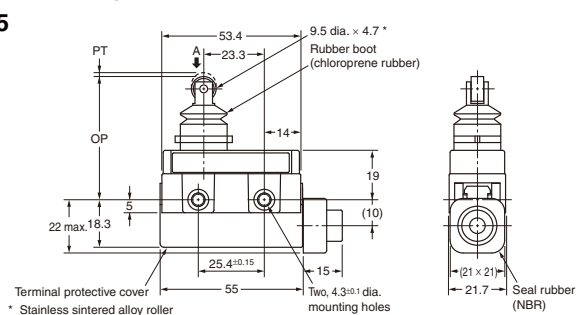
#### ZC-Q2155



Note: Do not use the M14 mounting screw and the case mounting hole at the same time.

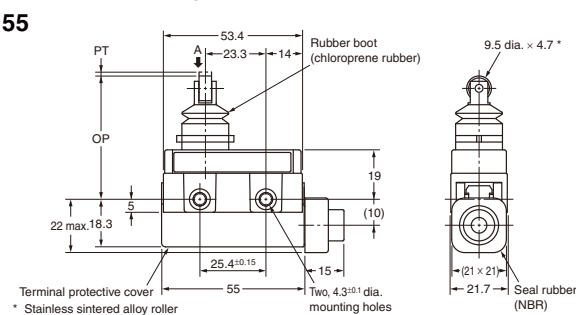
### Sealed Roller Plunger

#### ZC-N2255



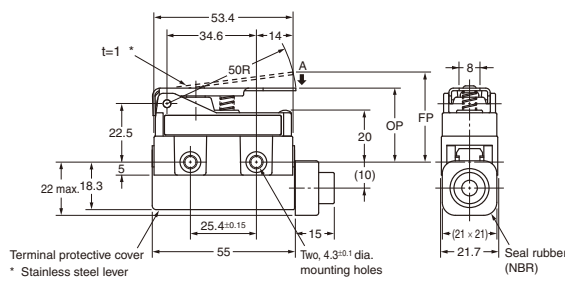
### Sealed Crossroller Plunger

#### ZC-N2155

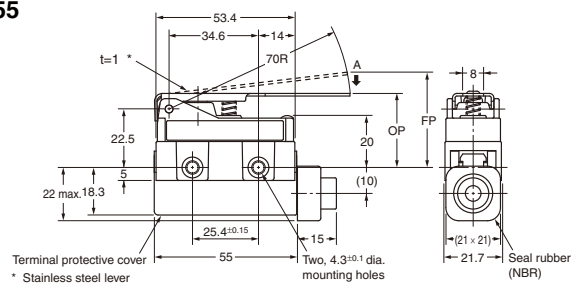


Note: 1. Unless otherwise specified, a tolerance of  $\pm 0.4$  mm applies to all dimensions.  
2. Operating characteristics are for when the Switch is operated from direction A.

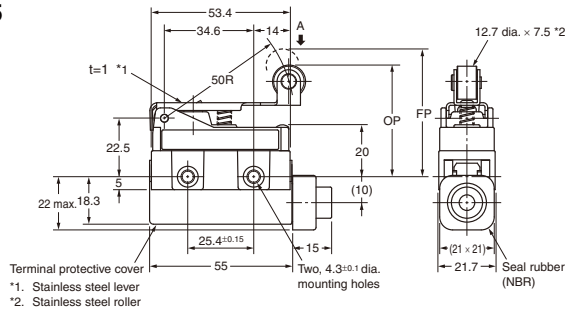
**Short Hinge Roller Lever**  
**ZC-W55**



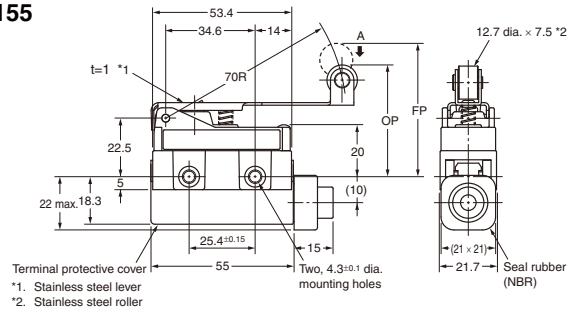
**Hinge Lever**  
**ZC-W155**



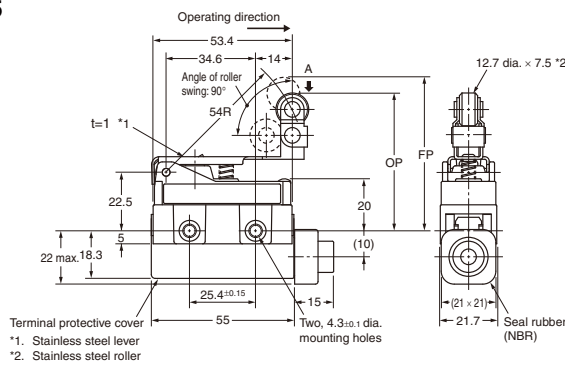
**Short Hinge Roller Lever**  
**ZC-W255**



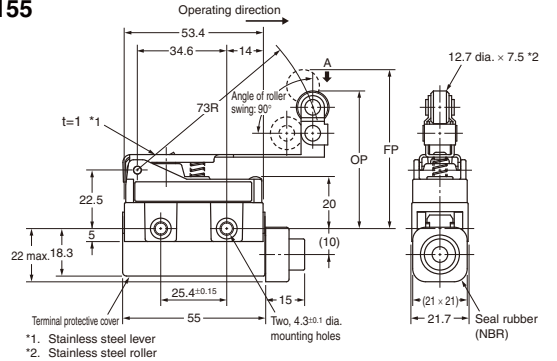
**Hinge Roller Lever**  
**ZC-W2155**



**One-way Action Short Hinge Roller Lever**  
**ZC-W355**



**One-way Action Hinge Roller Lever**  
**ZC-W3155**



Note: 1. Unless otherwise specified, a tolerance of ±0.4 mm applies to all dimensions.  
2. Operating characteristics are for when the Switch is operated from direction A.

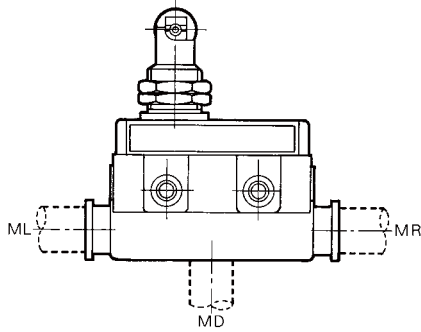
Operating Characteristics	Model	ZC-D55	ZC-Q55	ZC-Q2255	ZC-Q2155	ZC-N2255 *	ZC-N2155 *
Operating force	OF max.	11.8 N	11.8 N	11.8 N	11.8 N	6.86 N	6.86 N
Release force	RF min.	4.9 N	4.9 N	4.9 N	4.9 N	1.67 N	1.67 N
Pretravel	PT max.	1.5 mm	1.5 mm	1.5 mm	1.5 mm	1.5 mm	1.5 mm
Overtravel	OT min.	2.4 mm	3 mm	3 mm	3 mm	2.5 mm	2.5 mm
Movement Differential	MD max.	0.2 mm	0.2 mm	0.2 mm	0.2 mm	0.2 mm	0.2 mm
Free Position	FP max.	---	---	---	---	---	---
Operating Position	OP	32.4±0.8 mm	38.2±0.8 mm	47.4±0.8 mm	47.4±0.8 mm	47.4±0.8 mm	47.4±0.8 mm

\* Make sure that the permissible OT position is not exceeded.

Operating Characteristics	Model	ZC-W55	ZC-W155	ZC-W255	ZC-W2155	ZC-W355	ZC-W3155
Operating force	OF max.	3.92 N	2.75 N	3.92 N	2.75 N	3.92 N	2.75 N
Release force	RF min.	0.78 N	0.59 N	0.78 N	0.59 N	0.78 N	0.59 N
Pretravel	PT max.	---	---	---	---	---	---
Overtravel	OT min.	6 mm	8.4 mm	6 mm	8.4 mm	6 mm	8.4 mm
Movement Differential	MD max.	1 mm	1.4 mm	1 mm	1.4 mm	1 mm	1.4 mm
Free Position	FP max.	34.7 mm	36.7 mm	49.2 mm	51.3 mm	59.2 mm	61.2 mm
Operating Position	OP	28.5±1.2 mm	28.5±1.2 mm	43±1.2 mm	43±1.2 mm	53±1.2 mm	53±1.2 mm

**Molded Terminal Models  
(Not Approved by UL, CSA, or EN)**

Use of the molded terminal model is recommended in locations subject to excessive dust, oil drips, or moisture. All types of ZC Switches can be fabricated into a molded terminal version. In this case, the molded terminal model will have the same dimensions and operating characteristics as the basic model from which the molded terminal model is fabricated.



**Suffix by Location of Lead Outlet**

Location of lead output	Model (Suffix)
	COM, NC, NO
Right-hand	-MR
Left-hand	-ML
Underside	-MD

Note: The suffixes on the left can be added to the model numbers given on page 1 to specify molded terminals.

**Lead Supplies**

Leads	Speci- fica- tion	Nominal cross-sectional area (mm <sup>2</sup> )	External diameter (mm)	Terminal connec- tions	Length (m)
V.C.T. (vinyl cable)		1.25	3 conductor: 10.5 dia.	Black: COM White: NO Red: NC	1, 3

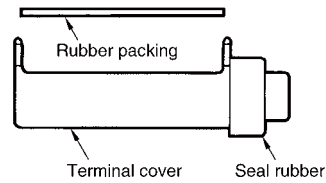
Note: When placing your order for the Switch, specify the required length of V.C.T. cable in addition to the model number of the Switch. Consult with your OMRON representative for other types of lead wires and for lead wires longer than 3 m.

**How to Order**

Example:  
Standard type: ZC-Q2255  
Location of lead output: Right side  
Length of lead: 1 m (V.C.T. lead)

When placing your order for the above Switch, specify the model number as ZC-Q2255-MR VCT 1M.

**Terminal Protective Cover, Seal Rubber, and Rubber Packing  
(The Switch is equipped with these 3 items as a standard.)**



- ZC Terminal Cover (Product code: ZC55-0002H)
- ZC Seal Rubber (Product code: SC-1404C)
- ZC Rubber Packing (Product code: ZC55-0003F)

### Operation Indicator-equipped Models (Not Approved by UL, CSA, or EN)

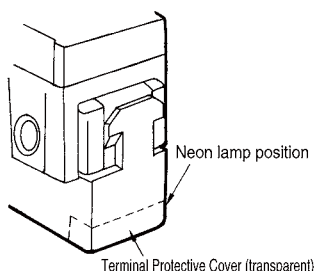
- All the models can be equipped upon request with a operation indicator to facilitate maintenance and inspection.
- Because the indicator is incorporated in the Terminal Protective Cover, the dimensions of the Limit Switch are not affected. In this model, the lead wire is to be connected to the screw terminal. (A connecting washer is provided on the tip of the lead wire). The lead wire can be connected to either the NC or NO terminal.
- Operating characteristics are the same as the standard model from which the operation indicator equipped model is fabricated.

#### (For AC)

- The operating voltage range is from 90 to 250 VAC.
- The dimensions are the same as the standard type. The top of the Terminal Protective Cover is transparent to allow checking the operation easily.
- When placing your order for the indicator equipped, AC-operated model, add suffix "L" to the end of the model number.

Example:

Standard type: ZC-Q2255  
 Indicator equipped type: ZC-Q2255-L

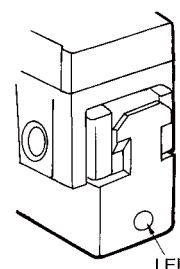


#### (For DC)

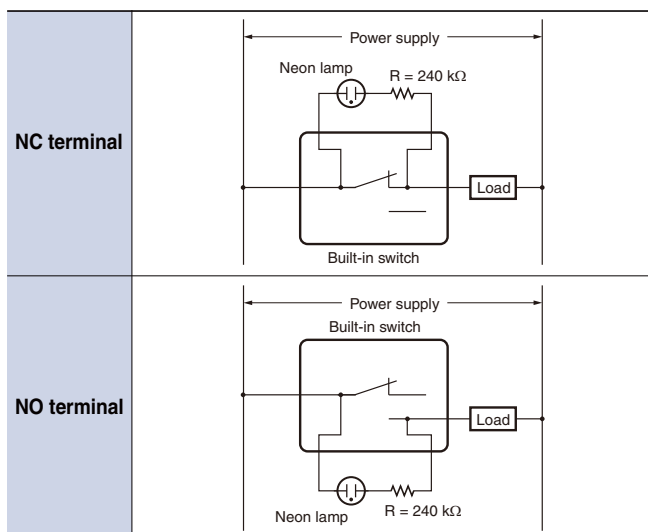
- The DC-operated is provided with an LED indicator.
- There is no protective structure.
- Since a rectifier stack is incorporated into the unit to permit reversing the polarity, this type can also operate on AC power source.
- The LED projects from the housing for easy visibility.
- When placing your order, add suffix "L2" or "L4" to the model number of the standard type.

Example:

Standard type: ZC-Q2255  
 Indicator equipped type: ZC-Q2255-L2



#### Contact Circuit

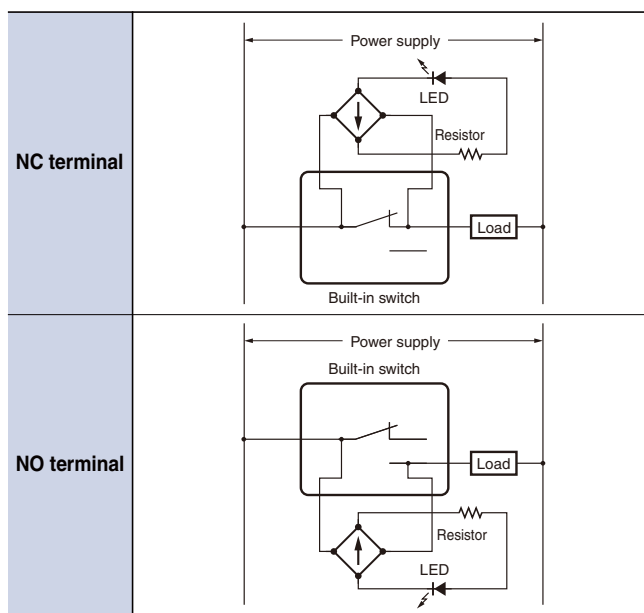


Note: If the wiring is as shown above, the operation of the respective parts will be as shown in the following table. The neon lamp is not wired when the Switch is delivered. Connect it as required.

Contact	Neon lamp	Load	Actuator
NC	ON	Does not operate	Operates
	OFF	Operates	Does not operate
NO	ON	Does not operate	Does not operate
	OFF	Operates	Operates

Model	Voltage rating (V)	Leakage current (mA)	Internal resistance (kΩ)
L2	12	Approx.2.4	4.3
L4	24	Approx.1.2	18

#### Contact Circuit



Note: If the wiring is as shown above, the operation of the respective parts will be as shown in the following table. The LED terminals are not wired when the Switch is delivered. Connect it as required.

Contact	LED	Load	Actuator
NC	ON	Does not operate	Operates
	OFF	Operates	Does not operate
NO	ON	Does not operate	Does not operate
	OFF	Operates	Operates



## Safety Precautions

For details, be sure to read *Safety Precautions for All Limit Switches*.

### Precautions for Correct Use

#### Operating Environment

- Seal material may deteriorate if a Switch is used outdoor or where subject to special cutting oils, solvents, or chemicals. Always appraise performance under actual application conditions and set suitable maintenance and replacement periods.
- Install Switches where they will not be directly subject to cutting chips, dust, or dirt. The Actuator and Switch must also be protected from the accumulation of cutting chips or sludge.



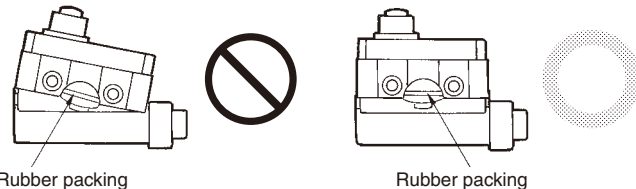
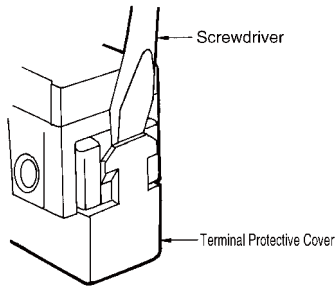
- Constantly subjecting a Switch to vibration or shock can result in wear, which can lead to contact interference with contacts, operation failure, reduced durability, and other problems. Excessive vibration or shock can lead to false contact operation or damage. Install Switches in locations not subject to shock and vibration and in orientations that will not produce resonance.
- The Switches have physical contacts. Using them in environments containing silicon gas will result in the formation of silicon oxide (SiO<sub>2</sub>) due to arc energy. If silicon oxide accumulates on the contacts, contact interference can occur. If silicon oil, silicon filling agents, silicon cables, or other silicon products are present near the Switch, suppress arcing with contact protective circuits (surge killers) or remove the source of silicon gas.

#### Dog Angle

When operating the roller type, be sure to set the dog angle to less than 30° (even when operating at a low speed). Operating the model at a dog angle exceeding 30° will soon cause abrasion or damage. Do not apply a twisting force to the plunger. Set the OT to 70% to 100% of the specified value so that the actuator will not exceed the OT.

#### Handling

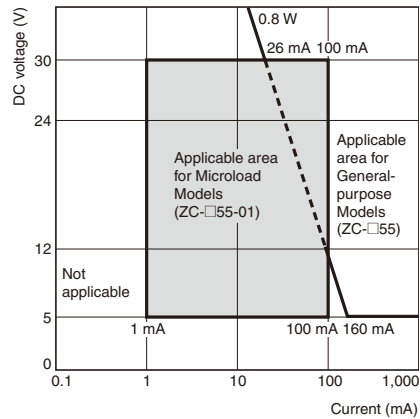
- When detaching the Terminal Protective Cover, insert a screwdriver and apply a force in the opening direction. Do not use excess force to remove the cover. Doing so may cause deformation in the fitting section and reduce the holding force.
- When mounting the Terminal Protective Cover to the case, align the cover on the case and then press the cover down to mount it firmly. If the cover is pressed down in an inclined position, rubber packing will deform and thus affect the sealing capability.



- A 8.5-dia. to 10.5-dia. cable can be applied as seal rubber for the lead wire outlet. (Use two- or three-core cable of VCT1.25 mm<sup>2</sup>.)
- Use weather-proof rubber (chloroprene rubber) as seal rubber for the ZC-N22(21)55.

#### Micro Load Models

Contact failure may occur if a General-purpose Switch is used to switch a microload circuit. Use Switches within the areas shown in the following chart. Even when using Microload Switches within the area shown below, contact wear will become more extreme with loads that generate surge current when switching and durability will be adversely affected. If necessary, insert a contact protective circuit. Microloads are indicated by N standard reference values. This value represents the failure rate at a 60% ( $\lambda_{60}$ ) reliability level. (JIS C5003) The equation  $\lambda_{60} = 0.5 \times 10^{-6}/\text{operations}$  indicates that a failure rate of 1/2,000,000 operations can be expected at a reliability level of 60%.

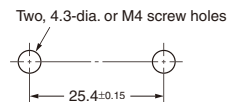


Model	ZC-□55-01	ZC-□55
Minimum applicable load	5 VDC 1mA	5 VDC 160mA

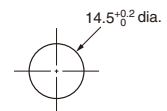
#### Mounting

- When mounting the Switch with screws on a side surface, fasten the Switch with M4 screws and use washers, spring washers, etc., to ensure secure mounting.
- When mounting the Panel Mount-type Enclosed Switch (ZC-Q55, ZC-Q2255, or ZC-Q2155) with screws on a side surface, remove the hexagonal nuts from the actuator.

#### Mounting Holes



#### Mounting Holes



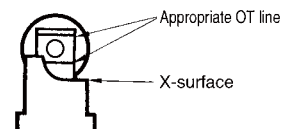
#### Appropriate Tightening Torque

A loose screw may result in a malfunction. Be sure to tighten each screw to the proper tightening torque as shown below.

No.	Type	Appropriate Tightening Torque
(1)	Terminal screw	0.78 to 1.18 N·m
(2)	Panel mounting screw	4.90 to 7.84 N·m
(3)	Side mounting screw	1.18 to 1.47 N·m

#### Operation

With the ZC-Q22(21)55, an appropriate OT line is marked on the plunger. Set the OT so that it is between the two X-surface lines.



# Precautions for All Limit Switches

(Not including Safety Switches)

**Note:** Refer to the *Precautions* section for each Switch for specific precautions applicable to each Switch.

## Precautions for Safe Use

- If the Switch is to be used as a switch in an emergency stop circuit or in a safety circuit for preventing accidents resulting in injuries or deaths, use a Switch with a direct opening mechanism, use the NC contacts with a forced release mechanism, and set the Switch so that it will operate in direct opening mode.  
For safety, install the Switch using one-way rotational screws or other similar means to prevent it from easily being removed. Protect the Switch with an appropriate cover and post a warning sign near the Switch in order to ensure the safety.
- Do not supply electric power when wiring. Otherwise electric shock may result.
- Keep the electrical load below the rated value.
- Be sure to evaluate the Switch under actual working conditions after installation.
- Do not touch the charged switch terminals while the Switch has carry current, otherwise electric shock may result.
- If the Switch has a ground terminal, be sure to connect the ground terminal to a ground wire.
- Do not disassemble the Switch while electric power is being supply. Otherwise electric shock may result.
- The durability of the Switch greatly varies with switching conditions. Before using the Switch, be sure to test the Switch under actual conditions. Make sure that the number of switching operations is within the permissible range.  
If a deteriorated Switch is used continuously, insulation failures, contact weld, contact failures, switch damage, or switch burnout may result.
- Maintain an appropriate insulation distance between wires connected to the Switch.
- Some types of load have a great difference between normal current and inrush current. Make sure that the inrush current is within the permissible value. The greater the inrush current in the closed circuit is, the greater the contact abrasion or shift will be. Consequently, contact weld, contact separation failures, or insulation failures may result. Furthermore, the Switch may become broken or damaged.



## Wiring

Pay the utmost attention so that each terminal is wired correctly. If the terminal is wired incorrectly, the Switch will not function. Furthermore, not only will the Switch have a bad influence on the external circuit, the Switch itself may become damaged or burnt.

## Mounting

- Do not modify the actuator, otherwise the operating characteristics and performance of the actuator will change.
- Do not enlarge the mounting holes of the Switch or modify the Switch. Doing so may result in insulation failures, housing damage, or physical injuries.
- Be sure to evaluate the Switch under actual working conditions after installation.
- Do not apply oil, grease, or other lubricants to the moving parts of the actuator, otherwise the actuator may not operate correctly. Furthermore, intrusion of oil, grease, or other lubricants inside the Switch may reduce sliding characteristic or cause failures in the Switch.
- Mount the Switch and secure it with the specified screws tightened to the specified torque along with flat washers and springs. The actuator of a Pushbutton Limit Switch mounted to a panel with excessive tightening torque may not operate correctly.
- Be sure to wire the Switch so that the conduit opening is free of metal powder or any other impurities.
- If glue or bonding agent is applied, make sure that it does not adhere to the movable parts or intrude inside the Switch, otherwise the Switch may not work correctly or cause contact failure. Some types of glue or bonding agent may generate a gas that may have a bad influence on the Switch. Pay the utmost attention when selecting the glue or locking agent.
- Do not drop or disassemble the Switch, otherwise the Switch will not be capable of full performance. Furthermore, the Switch may become broken or burnt.
- Some models allow changes in head directions. When changing the head of such a model, make sure that the head is free of any foreign substance. Tighten each screw of the head to the rated torque.
- Be sure to take measures so that no foreign material, oil, or water will penetrate into the Switch through the conduit opening. Be sure to attach a connector suited to the cable thickness and tighten the connector securely to the rated torque.
- Do not impose shock or vibration on the actuator while it is fully pressed. Otherwise, the actuator will partially abrade and an actuation failure may result.

## Wiring

- If the wiring method is incorrect, the wires may get caught on objects or the lead wires may be pulled excessively. Make sure that the lead wires are sufficiently long and secure them along the wiring path.



- Pay the utmost attention so that each terminal is wired correctly. If a terminal is wired incorrectly, the Limit Switch will not function properly. Furthermore, not only will the Limit Switch have an adverse influence on external circuits, the Limit Switch itself may become damaged or burnt.

## Precautions for Correct Use

For details, refer to *Precautions for Correct Use* in the *Technical Guide for Limit Switches*.



## Precautions for Correct Use

### Switch Operation

- The Switch in actual operation may cause accidents that cannot be foreseen from the design stage. Therefore, the Switch must be practically tested before actual use.
- When testing the Switch, be sure to apply the actual load condition together with the actual operating environment.
- All the performance ratings in this catalog are provided under the following conditions unless otherwise specified.

#### Inductive load:

A minimum power factor of 0.4 (AC) or a maximum time constant of 7 ms (DC)

#### Lamp load:

An inrush current 10 times higher than the normal current

#### Motor load:

An inrush current 6 times higher than the normal current

(1) Ambient temperature: +5°C to +35°C

(2) Ambient humidity: 40% to 70%RH

Note: An inductive load causes a problem especially in DC circuitry. Therefore, it is essential to know the time constants (L/R) of the load.



### Mechanical Characteristics

#### Operating Force, Stroke, and Contact Characteristics

- The following graph indicates the relationship between operating force and stroke or stroke and contact force. In order to operate the Limit Switch with high reliability, it is necessary to use the Limit Switch within an appropriate contact force range. If the Limit Switch is used in a normally closed condition, the dog must be installed so that the actuator will return to the FP when the actuator is actuated by the dog. If the Limit Switch is used in a normally open condition, the actuator must be pressed to 70% to 100% of the OT (i.e., 60% to 80% of the TT) and any slight fluctuation must be absorbed by the actuator.
- If the full stroke is set close to the OP or RP, contact instability may result. If the full stroke is set to the TTP, the actuator or switch may become damaged due to the inertia of the dog. In that case, adjust the stroke with the mounting panel or the dog. Refer to page 11, Dog Design, page 12, Stroke Settings vs. Dog Movement Distance, and page 12, Dog Surface for details.

- The following graph shows an example of changes in contact force according to the stroke. The contact force near the OP or RP is unstable, and the Limit Switch cannot maintain high reliability. Furthermore, the Limit Switch cannot withstand strong vibration or shock.



- If the Limit Switch is used so that the actuator is constantly pressed, it will fail quickly and reset faults may occur. Inspect the Limit Switch periodically and replace it as required.

#### Mechanical Conditions for Switch Selection

- The actuator must be selected according to the operating method. (Refer to page 9.)
- Check the operating speed and switching frequency.
  1. If the operating speed is extremely low, the switching of the movable contact will become unstable, thus resulting in incorrect contact or contact weld.
  2. If the operating speed is extremely high, the Switch may break due to shock. If the switching frequency is high, the switching of the contacts cannot catch up with the switching frequency. Make sure that the switching frequency is within the rated switching frequency.
- Do not impose excessive force on the actuator, otherwise the actuator may become damaged or not operate correctly.
- Make sure that the stroke is set within the suitable range specified for the model, or otherwise the Switch may break.

#### Electrical Characteristics

##### Electrical Characteristics for Switch Selection

- The switching load capacity of the Switch greatly varies between AC and DC. Always be sure to apply the rated load. The control capacity will drastically drop if it is a DC load. This is because a DC load has no current zero-cross point, unlike an AC load. Therefore, if an arc is generated, it may continue comparatively for a long time. Furthermore, the current direction is always the same, which results in a contact relocation phenomena whereby the contacts easily stick to each other and do not separate when the surfaces of the contacts are uneven.
- If the load is inductive, counter-electromotive voltage will be generated. The higher the voltage is, the higher the generated energy will be, which will increase the abrasion of the contacts and contact relocation phenomena. Be sure to use the Switch within the rated conditions.
- If the load is a minute voltage or current load, use a dedicated Switch for minute loads. The reliability of silver-plated contacts, which are used by standard Switches, will be insufficient if the load is a minute voltage or current load.

## Contact Protective Circuit

Apply a contact protective circuit to increase the contact durability, prevent noise, and suppress the generation of carbide or nitric acid. Be sure to apply the contact protective circuit correctly, otherwise an adverse effect may occur.

The following provides typical examples of contact protective circuits. If the Switch is used in an excessively humid location for switching a load that easily generates arcs, such as an inductive load, the arcs

may generate NO<sub>x</sub>, which will change into HNO<sub>3</sub> if it reacts with moisture.

Consequently, the internal metal parts may corrode and the Switch may fail. Be sure to select the ideal contact preventive circuit from the following.

Also, load operating times may be delayed somewhat if a contact protective circuit (a surge killer) is used.

## Typical Examples of Contact Protective Circuits

Circuit example	Applicable current		Feature and details	Element selection	
	AC	DC			
CR circuit		Conditional *	○	* When AC is switched, the load impedance must be lower than the CR impedance.	<p>C: 1 to 0.5 μF × switching current (A) R: 0.5 to 1 Ω × switching voltage (V)</p> <p>The values may change according to the characteristics of the load.</p> <p>The capacitor suppresses the spark discharge of current when the contacts are open. The resistor limits the inrush current when the contacts are closed again. Consider the roles of the capacitor and resistor and determine ideal capacitance and resistance values through testing.</p> <p>Generally, use a capacitor that has a dielectric strength of between 200 and 300 V. Use an AC capacitor for an AC circuit, i.e., a capacitor that has no polarity.</p> <p>If, however, the arc shutoff capacity between the contacts is a problem at high DC voltages, it may be more effective to connect a capacitor and resistor across the contacts rather than the load. Performing testing to determine the most suitable method.</p>
		○	○	The operating time will be greater if the load is a relay or solenoid. Connecting the CR circuit in parallel to the load is effective when the power supply voltage is 24 or 48 V and in parallel to the contacts when the power supply voltage is 100 to 200 V.	
Diode method		×	○	Energy stored in the coil is changed into current by the diode connected in parallel to the load. Then the current flowing to the coil is consumed and Joule heat is generated by the resistance of the inductive load. The reset time delay with this method is longer than that in the CR method.	The diode must withstand a peak inverse voltage 10 times higher than the circuit voltage and a forward current as high or higher than the load current.
Diode and Zener diode method		×	○	This method will be effective if the reset time delay caused by the diode method is too long.	If a suitable Zener voltage is not used, the load may fail to operate depending on the environment. Use a Zener diode with a Zener voltage that is about 1.2 times the power supply voltage.
Varistor method		○	○	This method makes use of constant-voltage characteristic of the varistor so that no high voltage is imposed on the contacts. This method causes a reset time delay. Connecting a varistor in parallel to the load is effective when the supply voltage is 24 to 48 V and in parallel to the contacts when the supply voltage is 100 to 200 V.	Select a varistor with a cut voltage V <sub>c</sub> that satisfies the following formula. For AC, the voltage must be multiplied by the square root of 2. V <sub>c</sub> > Power supply voltage × 1.5 If V <sub>c</sub> is set too high, effectiveness will be reduced because high voltages will not be cut.

Do not apply contact protective circuits (surge killers) as shown below.

		This circuit effectively suppresses arcs when the contacts are OFF. When the contacts are open, capacity is stored in the capacitor, and short-circuit current of the capacitor will flow when the contacts are turned ON, which may cause contacts to weld.
		This circuit effectively suppresses arcs when the contacts are OFF. When the contacts are ON again, however, charge current will flow to the capacitor, which may result in contact weld.

## Using Switches for Micro Loads

Contact faults may occur if a Switch for a general-load is used to switch a micro load circuit. Use switches in the ranges shown in the diagram on the right. However, even when using micro load models within the operating range shown here, if inrush current occurs when the contact is opened or closed, it may increase contact wear and so decrease durability. Therefore, insert a contact protection circuit where necessary. The minimum applicable load is the N-level reference value. This value indicates the malfunction reference level for the reliability level of 60% ( $\lambda_{60}$ ).

The equation,  $\lambda_{60} = 0.5 \times 10^{-6}/\text{operations}$  indicates that the estimated malfunction rate is less than 1/2,000,000 operations with a reliability level of 60%.



# Technical Guide for Limit Switches

## Connections

- Do not connect a Single Limit Switch to two power supplies that are different in polarity or type.

Power Connection Examples  
(Connection of Different Polarities)



Incorrect Power Connection Example  
(Connection of Different Power Supplies)  
There is a risk of AC and DC mixing.



Connect the load to the same polarities.

- Do not design a circuit where voltage is imposed between contacts, otherwise contact welding may result.



- Do not use a circuit that will short-circuit if an error occurs, otherwise the charged part may melt and break off.



- Application of Switch to a Low-voltage, Low-current Electronic Circuit.

- If bouncing or chattering of the contacts results and causes problems, take the following countermeasures.
    - Insert an integral circuit.
    - Suppress the generation of pulse from the contact bouncing or chattering of the contacts so that it is less than the noise margin of the load.
  - Conventional silver-plated contacts are not suited to this application. Use gold-plated contacts, which are ideal for handling minute voltage or current loads.
  - The contacts of the Switch used for an emergency stop must be normally closed with a positive opening mechanism.
- In order to protect the Switch from damage due to short-circuits, be sure to connect a quick-response fuse with a breaking current 1.5 to 2 times larger than the rated current to the Switch in series. When complying with EN approved ratings, use a 10-A IEC 60269-compliant gI or gG fuse.

## Operating Environment

- Do not use the Switch by itself in atmospheres containing flammable or explosive gases. Arcs and heating resulting from switching may cause fire or explosion.
- Use protective covers to protect Switches that are not specified as waterproof or airtight whenever they are used in locations subject to splattering or spraying oil or water, or to accumulation of dust or dirt.



- The materials of Limit Switch may change in quality or deteriorate if the Limit Switch is used outdoors or any other location where the Limit Switch is exposed to special machining oil. Consult your OMRON representative before selecting the model.
- Be sure to install the Switch so that the Switch is free from dust or metal powder. The actuator and the switch casing must be protected from the accumulation of dust or metal powder.



- Do not use the Switch in locations where the Switch is exposed to hot water at a temperature greater than 60°C or steam.
- Do not use the Switch under temperatures or other environmental conditions not within the specified ranges. The rated permissible ambient temperature range varies with the model. Refer to the specifications in this catalog. If the Switch is exposed to radical temperature changes, the thermal shock may deform the Switch and the Switch may malfunction.



- Be sure to protect the Switch with a cover if the Switch is in a location where the Switch may be actuated by mistake or where the Switch is likely cause an accident.



- If vibration or shock is continuously imposed on the Switch, contact failure, malfunction, or decrease in service life may be caused by abrasive powder generated from the internal parts. If excessive vibration or shock is imposed on the Switch, the contacts may malfunction or become damaged. Make sure to install the Switch in locations free of constant vibration or shock.
- Do not use the Switch with silver-plated contacts for long periods if the switching frequency of the Switch is comparatively low or the load is minute. Otherwise, sulfuric film will be generated on the contacts and contact failures may result. Use the Switch with gold-plated contacts or use a dedicated Switch for minute loads instead.

- Do not use the Switch in locations with corrosive gas, such as sulfuric gas ( $H_2S$  or  $SO_2$ ), ammonium gas ( $NH_3$ ), nitric gas ( $HNO_3$ ), or chlorine gas ( $Cl_2$ ), or high temperature and humidity. Otherwise, contact failure or corrosion damage may result.
- If the Switch is used in locations with silicone gas, arc energy may create silicon dioxide ( $SiO_2$ ) on the contacts and a contact failure may result. If there is silicone oil, silicone sealant, or wire covered with silicone close to the Switch, attach a contact protective circuit to suppress the arcing of the Switch or eliminate the source of silicone gas generation.

## Regular Inspection and Replacement

- If the Switch is normally closed with low switching frequency (e.g., once or less than once a day), a reset failure may result due to the deterioration of the parts of the Switch. Regularly inspect the Switch and make sure that the Switch is in good working order.
- In addition to the mechanical durability or electrical durability of the Switch described previously, the durability of the Switch may decrease due to the deterioration of each part, especially rubber, resin, and metal. Regularly inspect the Switch and replace any part that has deteriorated in order to prevent accidents from occurring.
- If the Switch is not turned On or OFF for a long time, oxidation of the contacts may decrease contact reliability. Faulty continuity may result in accidents.
- Be sure to mount the Switch securely in a clean location to ensure ease of inspection and replacement. The Switch with operation indicator is available, which is ideal if the location is dark or does not allow easy inspection or replacement.



## Storage of Switch

- When storing the Switch, make sure that the location is free of corrosive gas, such as  $H_2S$ ,  $SO_2$ ,  $NH_3$ ,  $HNO_3$ , or  $Cl_2$ , or dust and does not have a high temperature or humidity.
- Be sure to inspect the Switch before use if it has been stored for three months or more.

## Weather Resistance, Cold Resistance, and Heat Resistance

Silicon rubber is used to increase resistance to weather, cold, and heat. Silicon rubber, however, can generate silicon gas. (This can occur at room temperature, but the amount of silicon gas generated increases at higher temperatures.) Silicon gas will react as a result of arc energy and form silicon oxide ( $SiO_2$ ). If silicon oxide accumulates on the contacts, contact interference can occur and can interfere with the device. Before using a Switch, test it under actual application conditions (including the environment and operating frequency) to confirm that no problems will occur in actual.

## Outdoor Use

- If the Limit Switch is used in places with sludge or dust powder spray, make sure that the mechanical parts are sealed with a rubber cap.
- The rubber materials exposed to ozone may deteriorate. Check that the rubber parts are made of environment-resistive materials, such as chloroprene, silicone, or fluorine rubber.
- Due to capillary attraction, rainwater may enter the Limit Switch through the lead wires or sheath. Be sure to cover the wire connections in a terminal box so that they are not directly exposed to rainwater.
- If the Limit Switch is used outdoors, the steel parts of the Limit Switch (such as the screws and plunger parts) may corrode. Models with resistance against climatic conditions have been added to the series. Consider using outdoor models, such as the WL-□P1 or D4C-□P.
- "Limit Switch is used outdoors" refers to an environment where the Limit Switch is exposed directly to rainwater or sunlight (e.g., multistory parking facilities) excluding locations with corrosive gas or salty breezes. A Limit Switch used outdoors may not release due to icing and may not satisfy specified standards.

## Operation

- Carefully determine the position and shape of the dog or cam so that the actuator will not abruptly snap back, thus causing shock. In order to operate the Limit Switch at a comparatively high speed, use a dog or cam that keeps the Limit Switch turned ON for a sufficient time so that the relay or valve will be sufficiently energized.
- The method of operation, the shape of the cam or dog, the operating frequency, and the travel after operation have a large influence on the durability and operating accuracy of the Limit Switch. The cam or dog must be smooth in shape.

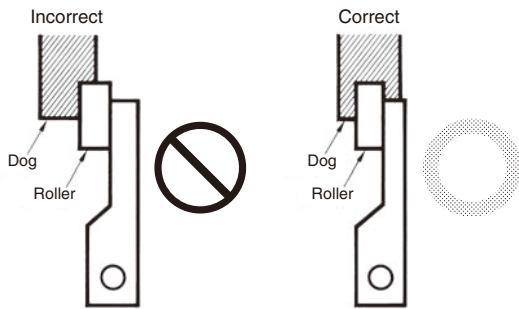


- Appropriate force must be imposed on the actuator by the cam or dog in both rotary operation and linear operation. If the dog touches the lever as shown below, the operating position will not be stable.



# Technical Guide for Limit Switches

- Unbalanced force must not be imposed on the actuator. Otherwise, wear and tear on the actuator may result.



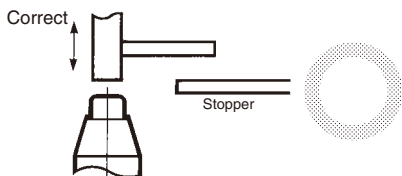
- With a roller actuator, the dog must touch the actuator at a right angle. The actuator or shaft may deform or break if the dog touches the actuator (roller) at an oblique angle.



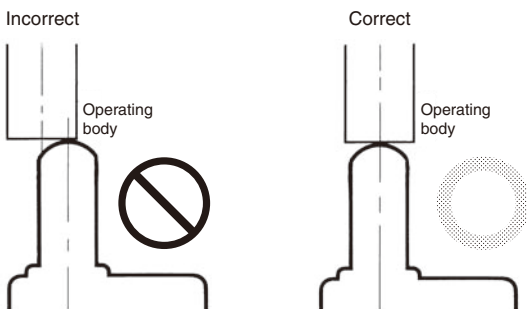
- Make sure that the actuator does not exceed the OT (overtravel) range, otherwise the Limit Switch may malfunction. When mounting the Limit Switch, be sure to adjust the Limit Switch carefully while considering the whole movement of the actuator.



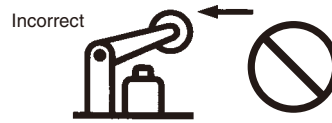
- The Limit Switch may soon malfunction if the OT is excessive. Therefore, adjustments and careful consideration of the position of the Limit Switch and the expected OT of the operating body are necessary when mounting the Limit Switch.



- When using a pin-plunger actuator, make sure that the stroke of the actuator and the movement of the dog are located along a single straight line.



- Be sure to use the Limit Switch according to the characteristics of the actuator. If a roller arm lever actuator is used, do not attempt to actuate the Limit Switch in the direction shown below.



- Do not modify the actuator to change the OP.
- With the long actuator of an Adjustable Roller Lever Switch, the following countermeasures against lever shaking are recommended.
  1. Make the rear edge of the dog smooth with an angle of 15° to 30° or make it in the shape of a quadratic curve.
  2. Design the circuit so that no error signal will be generated.
  3. Use a switch that is actuated in one direction only. (Alternatively, set the Switch so that it is operated only in one direction.)
- With a bevel plunger actuator, make sure that the width of the dog is wider than that of the plunger.





## Dog Design

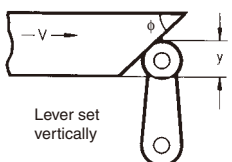
### Speed and Angle of Dog and Relationship with Actuator

Before designing a dog, carefully consider the operating speed and angle of the dog ( $\phi$ ) and their relationship with the shape of the actuator. The optimum operating speed ( $V$ ) of a standard dog at an angle of  $30^\circ$  to  $45^\circ$  is 0.5 m/s maximum.

### Roller Lever Switches

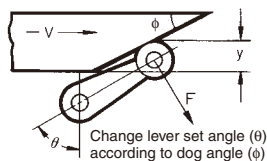
#### (1) Non-overtravel Dog

**Dog speed: 0.5 m/s max. (standard speed)**



$\phi$	V max. (m/s)	y
$30^\circ$	0.4	0.8 (TT)
$45^\circ$	0.25	80% of total travel
$60^\circ$	0.1	
$60^\circ$ to $90^\circ$	0.05 (low speed)	

**Dog speed:  $0.5 \text{ m/s} \leq V \leq 2 \text{ m/s}$  (high speed)**

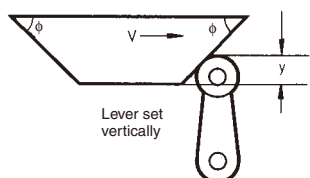


$\theta$	$\phi$	V max. (m/s)	y
$45^\circ$	$45^\circ$	0.5	0.5 to 0.8 (TT)
$50^\circ$	$40^\circ$	0.6	0.5 to 0.8 (TT)
$60^\circ$ to $55^\circ$	$30^\circ$ to $35^\circ$	1.3	0.5 to 0.7 (TT)
$75^\circ$ to $65^\circ$	$15^\circ$ to $25^\circ$	2	0.5 to 0.7 (TT)

Note: The above y values indicate the ratio ranges based on TT (total travel). Therefore, the optimum pressing distance of the dog is between 50% and 80% (or 50% and 70%).

#### (2) Overtravel Dog

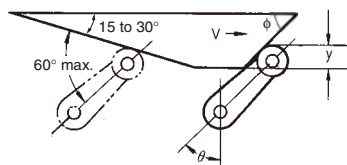
**Dog speed: 0.5 m/s max.**



$\phi$	V max. (m/s)	y
$30^\circ$	0.4	0.8 (TT)
$45^\circ$	0.25	80% of total travel
$60^\circ$	0.1	
$60^\circ$ to $90^\circ$	0.05 (low speed)	

**Dog speed: 0.5 m/s min.**

If the speed of the overtravel dog is comparatively high, make the rear edge of the dog smooth at an angle of  $15^\circ$  to  $30^\circ$  or make it in the shape of a quadratic curve. Then lever shaking will be reduced.



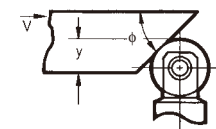
$\theta$	$\phi$	V max. (m/s)	y
$45^\circ$	$45^\circ$	0.5	0.5 to 0.8 (TT)
$50^\circ$	$40^\circ$	0.6	0.5 to 0.8 (TT)
$60^\circ$ to $55^\circ$	$30^\circ$ to $35^\circ$	1.3	0.5 to 0.7 (TT)
$75^\circ$ to $65^\circ$	$15^\circ$ to $25^\circ$	2	0.5 to 0.7 (TT)

Note: The above y values indicate the ratio ranges based on TT (total travel). Therefore, the optimum pressing distance of the dog is between 50% and 80% (or 50% and 70%).

### Plunger Switches

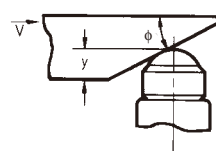
If the dog overrides the actuator, the front and rear of the dog may be the same in shape, provided that the dog is not designed to be separated from the actuator abruptly.

**Roller Plunger**



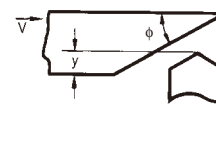
$\phi$	V max. (m/s)	y
$30^\circ$	0.25	0.6 to 0.8 (TT)
$20^\circ$	0.5	0.5 to 0.7 (TT)

**Ball Plunger**



$\phi$	V max. (m/s)	y
$30^\circ$	0.25	0.6 to 0.8 (TT)
$20^\circ$	0.5	0.5 to 0.7 (TT)

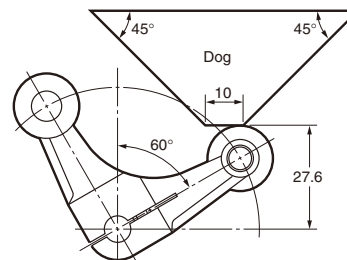
**Bevel Plunger**



$\phi$	V max. (m/s)	y
$30^\circ$	0.25	0.6 to 0.8 (TT)
$20^\circ$	0.5	0.5 to 0.7 (TT)

Note: The above y values indicate the ratio ranges based on TT (total travel). Therefore, the optimum pressing distance of the dog is between 60% and 80% (or 50% and 70%).

### Fork Lever Lock Models

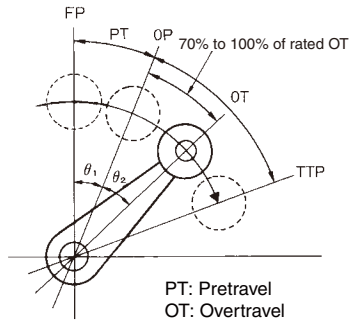


Note: Design the shape of the dog so that it does not come in contact with the other roller lever when the actuator is inverted.



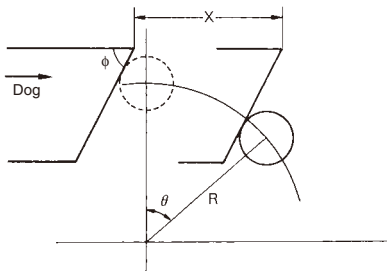
## Stroke Settings vs. Dog Movement Distance

- The following information on stroke settings is based on the movement distance of the dog instead of the actuator angle. The following is the optimum stroke of the Limit Switch.  
Optimum stroke:  $PT + \{Rated\ OT \times (0.7\ to\ 1.0)\}$   
In terms of angles, the optimum stroke is expressed as  $\theta_1 + \theta_2$ .



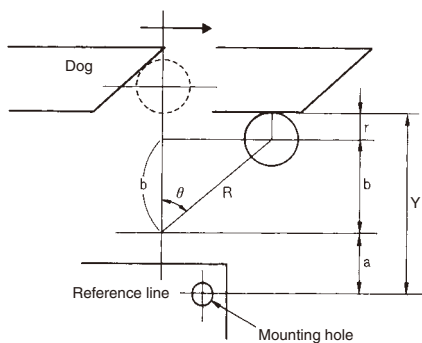
- The movement distance of the dog based on the optimum stroke is expressed by the following formula.  
Movement distance of dog

$$X = R \sin \theta + \frac{R (1 - \cos \theta)}{\tan \phi} \text{ (mm)}$$



- $\phi$ : Dog angle
- $\theta$ : Optimum stroke angle
- R: Actuator length
- X: Dog movement distance

- The distance between the reference line and the bottom of the dog based on the optimum stroke is expressed by the following formula.  
 $Y = a + b + r$  (mm)



- a: Distance between reference line and actuator fulcrum
- b:  $R \cos \theta$
- r: Roller radius
- Y: Distance between reference line and bottom of dog

## Dog Surface

The surface of dog touching the actuator should be 6.3 S in quality and a hardness of approximately HV450. For smooth operation of the actuator, apply molybdenum disulfide grease to the actuator and the dog touching the actuator. This is ideal for Limit Switches of drip-proof construction and Multiple Limit Switches.

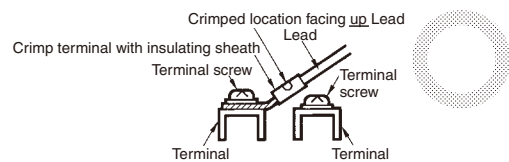
## Maintenance and Repairs

The user of the system must not attempt to perform maintenance and repairs. Contact the manufacturer of the system concerning maintenance and repairs.

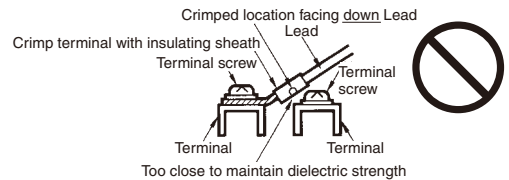
## Other

- The standard material for the switch seal is nitrile rubber (NBR), which has superior resistance to oil. Depending on the type of oil or chemicals in the application environment, however, NBR may deteriorate, e.g., swell or shrink. Confirm performance in advance.
- The correct Switch must be selected for the load to ensure contact reliability. Refer to precautions for micro loads in individual product information for details.
- When using a Limit Switch with a long lever or long rod lever, make sure that the lever is in the downward direction.
- Wire the leads as shown in the following diagram.

### Correct Wiring



### Incorrect Wiring



- Reduced ambient temperature tends to result in hardening of the actuator's rubber seal. Therefore, reset may be delayed or reset may fail if the Switch is used with the actuator continually pressed in. Contact your OMRON representative if the Switch is to be used for this type of environment or application.

## Read and Understand This Catalog

Please read and understand this catalog before purchasing the products. Please consult your OMRON representative if you have any questions or comments.

## Warranty and Limitations of Liability

### WARRANTY

OMRON's exclusive warranty is that the products are free from defects in materials and workmanship for a period of one year (or other period if specified) from date of sale by OMRON.

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## Application Considerations

### SUITABILITY FOR USE

OMRON shall not be responsible for conformity with any standards, codes, or regulations that apply to the combination of products in the customer's application or use of the product.

At the customer's request, OMRON will provide applicable third party certification documents identifying ratings and limitations of use that apply to the products. This information by itself is not sufficient for a complete determination of the suitability of the products in combination with the end product, machine, system, or other application or use.

The following are some examples of applications for which particular attention must be given. This is not intended to be an exhaustive list of all possible uses of the products, nor is it intended to imply that the uses listed may be suitable for the products:

- Outdoor use, uses involving potential chemical contamination or electrical interference, or conditions or uses not described in this catalog.
- Nuclear energy control systems, combustion systems, railroad systems, aviation systems, medical equipment, amusement machines, vehicles, safety equipment, and installations subject to separate industry or government regulations.
- Systems, machines, and equipment that could present a risk to life or property.

Please know and observe all prohibitions of use applicable to the products.

NEVER USE THE PRODUCTS FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON PRODUCT IS PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.

## Disclaimers

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