

# Vacuum interrupters

## Introduction



The first vacuum interrupter used commercially was a Jennings device. It was installed as a line-and-load dropping switch for a 138 kV transmission line in California in 1955. Jennings has continually expanded its portfolio of vacuum products, including a wide range of vacuum interrupters.

Current interruption in a vacuum is recognized as the ideal switching technology in the medium-voltage range, and it's also applied in high-voltage and low-voltage applications. Excellent switching capabilities and compact design make vacuum interrupters the most economical switching device solutions possible.

Jennings interrupter designs handle a wide range of voltage and current interrupt levels, and high quality and highly reliable interrupters are available for the utility and industrial markets.

### Design

Jennings vacuum interrupters feature an evacuated ceramic insulating envelope surrounding two contacts, one fixed and one movable.

The movable contact is operated from the outside through a metallic bellows. Contacts are typically a copper alloy that is developed for use in AC voltage applications. The end plates are made of stainless steel or copper.

### Features and benefits

- Long life, high reliability — Vacuum interrupters can be expected to last the life of the equipment in which they are installed
- Controlled contact erosion results in virtually maintenance-free operation
- Fast interrupting speed — The interruption mechanism is independent of current magnitude, so interruption can normally be anticipated at the first current zero with no restriking
- Rapid dielectric recovery — The dielectric strength of the contact gap recovers more rapidly than the recovery voltage can rise, eliminating restriking
- High cycle withstand voltages
- Robust, compact design — Vacuum dielectric enables contacts to be arranged close together so circuit interruptions can be designed in a smaller envelope
- Environmentally friendly — Current interruption occurs in a vacuum, so there is no emission of greenhouse or toxic gases
- Atmospheric contact contamination is eliminated — Oxides and corrosion layers cannot form in the vacuum environment
- Noise-free and flash-free — All arcing is confined within the vacuum interrupter body

### Applications

- Load break switches
- Contactors for industrial and motor control (example: Jennings contactors use Jennings vacuum interrupters)
- Capacitor bank switching
- Circuit breakers
- Specialty RF and DC applications

### Markets

- Power distribution
- Power transmission
- Industrial
- Airport
- Steel smelters
- Offshore drilling
- Mining
- Rail

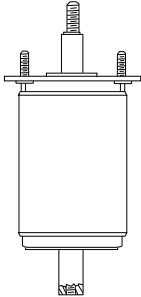



# Vacuum interrupters

## Product offering and selection guide


### Product offering

Electrical characteristics										
Cat. no.	Operating voltage (kV)	1 Minute DWV (kV)	Rated short circuit current (A RMS)	Rated continuous current (A RMS)	Contact force at contact separation (lbs. max.)	Mechanical life (operations)	Body diameter (in.)	Body length (in.)	Total length (in.)	Stroke (contact gap, in.)
RP158	3.6	45	N/A	300	7.7±20%	2.0 million	2.44	2.81	4.49	0.110
RP133	1.5	30	N/A	450	9.7±25%	500,000	2.06	2.25	3.275	0.090
RP233	25.0	40	N/A	35 A RMS @ 32 MHz	2 lbs. 8 oz.	1.5 million	1.31	4.18	5.68	0.120
RP173	7.2	28	6,000	450	16.5+ 25%	1.0 million	2.40	4.63	6.84	0.190
RP175	7.2	28	6,000	450	16.5+ 25%	1.0 million	3.00	4.75	7.83	0.190

### Selection guide

	RP175	RP173	RP158	RP133
Contactor and switch application — commercial				
Operating voltage	7.2 kV	7.2 kV	3.6 kV	1.5 kV
Rated continuous current	450 A	450 A	300 A	450 A

\* Capacitive switch rating

	RP233
RF/DC application	
Operating voltage	40 kV
Rated continuous current	35 A @ 32 MHz

# Vacuum interrupters

## Applications



### Industrial applications

The unique advantages of switching in a vacuum make vacuum interrupters useful in industrial applications. Many kinds of test, production or processing equipment have requirements for long contact life without maintenance, for low-cost high-voltage control or for sealed contacts because of difficult environmental requirements. Due to recent advances in vacuum interrupter technology and the availability of new low-cost designs, vacuum interrupters are finding many new uses.

Where voltages are high and fault currents relatively low, a vacuum interrupter switch is an attractive alternative to oil circuit breakers. They are smaller, less expensive to install and maintain, provide half-cycle interruption instead of requiring five cycles or more and eliminate danger of explosion and fire.

Vacuum interrupter switches are useful where dust, high humidity or high altitudes make it difficult to maintain dielectric strength with other types of devices. In airborne equipment, for example, their small size is also an important feature. In environments involving explosive or corrosive atmospheres, they provide an additional safety factor. Even when destroyed by high currents, the arc is still completely contained because not enough gas pressure is developed to destroy the protective envelope.

For dielectric and induction heating equipment and x-ray and irradiation equipment used for processing foods and chemicals, vacuum switches can be used directly in the DC circuits for fast, maintenance-free, push-button disconnect.

### RF switches

Vacuum interrupter switches have demonstrated superior performance for RF applications, such as:

- Band switching of transmitters
- Switching of filter sections and antenna multicouplers
- Antenna reflector switching
- Tap changing of RF coils in induction and dielectric heating RF generators
- Switching of transmission lines

Most of these applications are in the HF band and involve currents ranging from 20 amperes to several hundred amperes. At very high currents, switches should be fed symmetrically to avoid uneven current distribution inside the switch. Vacuum interrupter switches, without an actuator, lend themselves to custom-designed tap changing and filter network switching because a number of switches can be driven by cams from a common shaft.

# Vacuum contactors

## Overview

### Jennings vacuum contactors offer one of the most reliable means available for remotely controlling electric power

Jennings vacuum contactors provide all the operating advantages of a vacuum interrupter plus the benefits of a matching actuator to meet specific application requirements. These low and medium voltage contactors offer the most reliable means of remotely controlling electric power.

### Maintenance-free vacuum contactors provide fast arc extinction and rapid recovery of dielectric strength

Jennings contactors consist of a vacuum interrupter and an actuator linked together by an insulated actuating rod. Linkage and stand-off posts that isolate the high voltage from ground are made of epoxy glass laminate for DC switching. Heavy-duty connectors are provided for the high voltage connection.

Figure 1 illustrates a solenoid-operated vacuum contactor. Its interrupter consists of an evacuated ceramic insulating envelope in which there are two contacts, one stationary and one movable. The movable contact is operated from the outside through a metallic bellows that provides a vacuum-tight seal.

A vacuum has an extremely high dielectric strength — as high as 1000 volts per mil. When the contacts are opened to interrupt current flow, metal vapor is generated by the passage of current through the contacts. The vapor sustains the arc that is created, maintaining it down to or near current zero.

The small arc drawn on the contact opening is quickly extinguished because there are no gases, and there is only a small voltage drop across it. As the arc extinguishes, the metallic vapor rapidly diffuses outward and condenses on the cool surface of the vapor shields. The vapor shields prevent the metallic vapor from depositing on the ceramic insulating surfaces.

Fast arc extinction and rapid recovery of dielectric strength after contact opening are characteristics of vacuum interrupters. A phenomenon with these interrupters is the auto-maintenance of the vacuum. The metallic ions released from the contacts provide a gettering action. Tests have shown that frequent operation of the contacts produces a steady improvement in vacuum level because the released metallic ions actually remove gas molecules from the evacuated space. This ion-pumping action tends to maintain the vacuum near the high initial value.

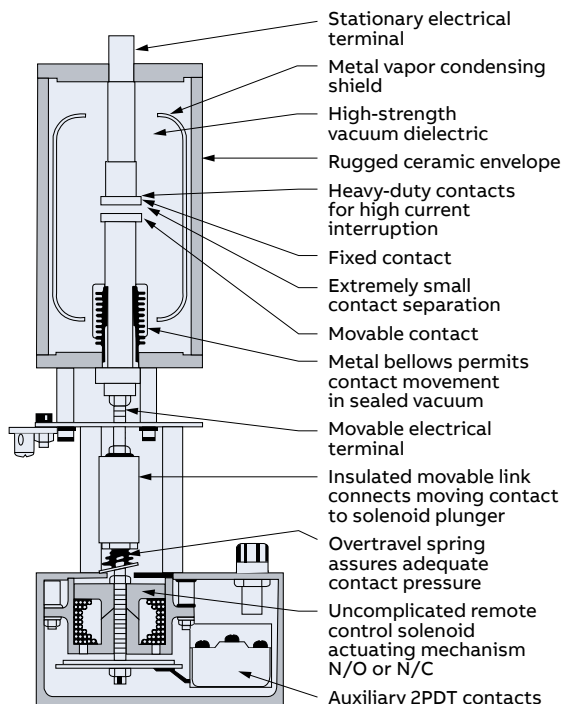


Figure 1 — typical Jennings solenoid-operated vacuum contactor



# Vacuum contactors

## Overview

### Typical applications

Jennings vacuum power contactors are used for controlling DC and 50/60/400 Hz circuits. Principal use is in high power electrical equipment requiring long contact life without maintenance, low-cost, high voltage control or sealed contacts because of environmental conditions.

Switching and protecting transformers used in DC power supplies is one of the most common power frequency applications for contactors. Most transformer switching is done on the primary side for off-on control or to switch out current-limiting resistors or reactors used for reduced-voltage starting of power tubes. It may be necessary to use additional backup fault protection to take care of primary line-side faults. This is sometimes accomplished using a current-limiting fuse or coordinating with a high capacity system breaker already located in the primary side. However, where frequent faults are anticipated, contactors offer a much longer life with no contact maintenance, and they are often less expensive.

### Advantages of Jennings vacuum contactors

By employing proven Jennings vacuum interrupter technology, Jennings contactors provide reliable, maintenance-free operation in industrial motor controls and other systems using a wide range of currents and voltages. The operation of contacts within a vacuum offers several inherent advantages:

- No required contact maintenance — Contacts are sealed within a very high vacuum and remain clean permanently. There is no contact oxidation or possibility of foreign matter forming on the contacts and leaving contaminating residues.
- Long life — The arc that results as the contact is made or broken is quickly extinguished within a vacuum. The special contact material utilized erodes at an extremely slow rate to provide reliable operation for tens of thousands of operations.
- Environmental safety factor — Vacuum contactors can be used in environments involving corrosive atmospheres because there is no exposed arcing during interruption.
- Compact, reliable operating mechanism — The high dielectric strength of a vacuum minimizes the contact-to-contact gap required to interrupt current. This short contact stroke not only provides high operating speed, but also reduces the size and weight of the operating mechanism used.
- No arc chute replacement — Ordinary air-break contactors require fragile arc chutes to extinguish the arc that forms when the contact is broken. Arc chutes are damaged with use and ultimately require replacement. The manner in which vacuum contactors operate causes the arc to be extinguished rapidly with minimal damage or wear.
- Proven operation — Jennings vacuum interrupters have been supplied for several decades for use in electrical power generation and distribution systems operating at all voltage levels. The long life and reliability of these devices is such that many of the original units are still in operation.
- Low contact resistance — This resistance remains low and stable for the life of the contactor.



# Vacuum contactors

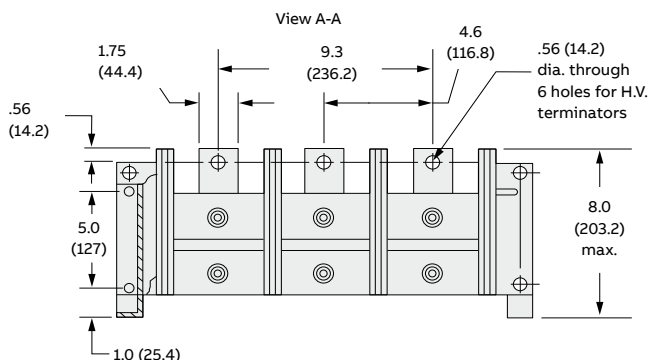
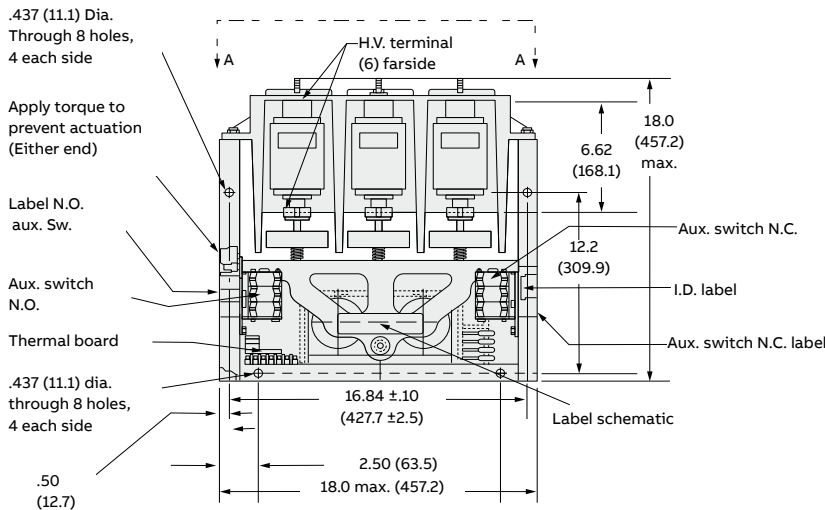
## RP173 three-phase vacuum contactors



Measuring 18"H x 18"W x 8"D and weighing less than 67 lbs., the Jennings RP173 three-phase vacuum contactor is built tough to work in a variety of heavy-duty applications. Able to withstand the frequent switching required to control furnaces and large motors, this contactor can also be used to switch power transformers and capacitor banks for voltage regulation and power factor correction as a means of reducing operating costs. It is ideal for use in motor controllers that operate production and processing equipment, mining and petroleum equipment, earth movers and conveyors, power shovels and all types of industrial loads. Using a trio of Jennings vacuum interrupters, the three-phase unit provides a short contact-to-contact gap required to interrupt the circuit for highly reliable operation. The contact materials are rated for 7.2 kV, 600 amp load life and 6000 amp fault current.

### Features

- Sealed main contacts provide a minimum of 1 million maintenance-free open and close operations
- Reliable operation in harsh temperature extremes ranging from -20 °C to 70 °C
- Versatility for use with heavy-duty motors, power equipment and motor controllers

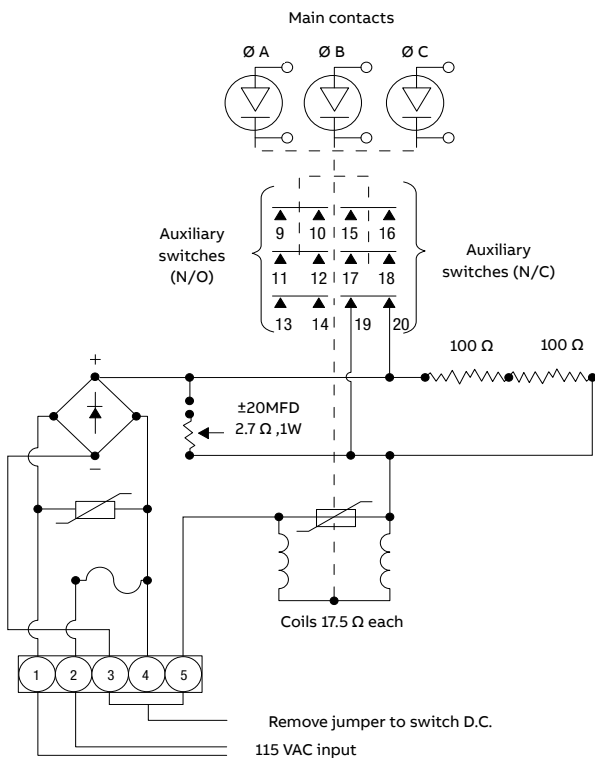


# Vacuum contactors

## RP173 three-phase vacuum contactors



Units shown in de-energized position.  
RP173-2310-XX shown.



Voltage ratings	
Maximum three-phase line (kV)	1.5, 2.5, 5.0, 7.2
Dielectrics 50/60/400 Hz, 60-second withstand	
— Line-to-ground (kV RMS)	30
— Line-to-line (kV RMS)	30
— Across open contacts (kV RMS)	30
BIL, 1.2 x 50 µsec impulse	
— Line-to-ground peak (kV)	20
— Line-to-line peak (kV)	20
Current rating	
Continuous (amps RMS)	450/600
Load-switching (amps RMS)	450
— Capacitors (grounded neutral)	2000 kVAR @ 4.16 kV
— Motors	5000 HP @ 7.2 kV
— Transformers	5000 kVA @ 7.2 kV
Making current (random make)	
— 100 Times @ 7.2 kV with 3-second backup (kA RMS)	4.5
— 10 Times @ 7.2 kV with current-limiting fuse (kA)	55 peak
— 100 Times @ 5.0 kV with 3-second backup (kA RMS)	6
Minimum load life @ 600 amps RMS	1 million open/close operations
Interrupt (amps RMS @ 5.0 kV)	6000

Actuator	
Control voltage	
— RP173-2310-XX	115 VAC, 50/60 Hz or
— RP173-2311-XX	110 VDC
230VAC, 50/60 Hz or 220VDC	
Control current	3.3 pull-in amps, 0.5 hold-in amp
Auxiliary contacts configuration	2 N/C, 3 N/O, SPST double break, 10 amps resistive @ 600 VAC

Mechanical	
Weight (lb.)	67 max.
Release time (msec.) from control switch off to separation of main contacts	100 max.
Mounting	Operates in any position

### RP173 three-phase vacuum contactors

Cat. no.	Mounting option	Actuator volts	Line-to-line voltage (RMS)
RP173-2310-00	Standard	115 VAC/110 VDC	7200
RP173-2310-01*	Standard	115 VAC/110 VDC	7200
RP173-2311-00	Standard	230 VAC/220 VDC	7200
RP173-2315-00**	View A-A 180°	115 VAC/110 VDC	7200
RP173-2341-00	Standard	115 VAC/ 110 or 120 VDC	7200

\* Includes ruggedized frame.

\*\* Modified for slower release time.

# Vacuum contactors

## RP133 three-phase vacuum contactors

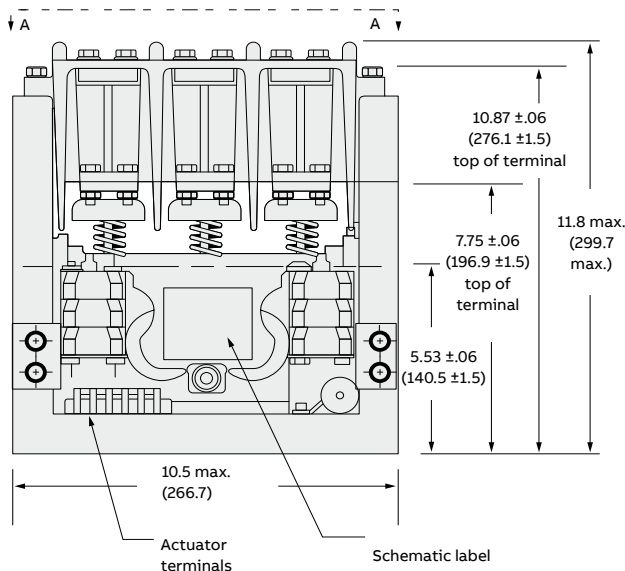
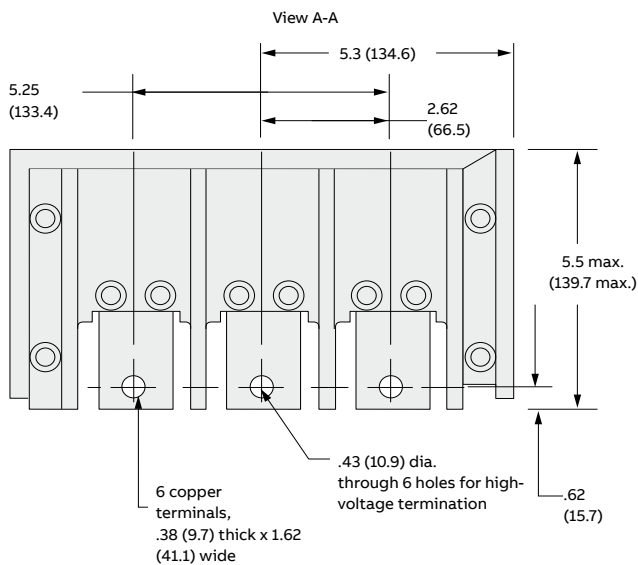


The Jennings RP133 vacuum contactor may be small — only 11.8"H x 10.5"W x 5.5"D — and weigh less than 30 pounds, but it can take on requirements of the most demanding equipment. Using a trio of Jennings vacuum interrupters, the three-phase unit provides a short contact-to-contact gap required to interrupt the circuit for highly reliable operation. The contact materials are rated for 1.5 kV, 450 amp load life and 4500 amp fault current.

Designed to withstand the frequent switching required to control furnaces and large air conditioning motors, the RP133 is commonly used to protect power transformers and DC power supplies. Use it to switch capacitor banks for voltage regulation and power factor correction as a means of reducing operating costs. Reliable and durable, the RP133 can also be used in motor controllers that operate production and processing equipment, mining and construction equipment, earth movers or carriers, power shovels, rock crushers and conveyors.

### Features

- Sealed main contacts provide a minimum of 1 million maintenance-free open and close operations
- Reliable operation in harsh temperature extremes ranging from -20 °C to 70 °C
- Versatility for use with heavy-duty motors, power equipment and motor controllers



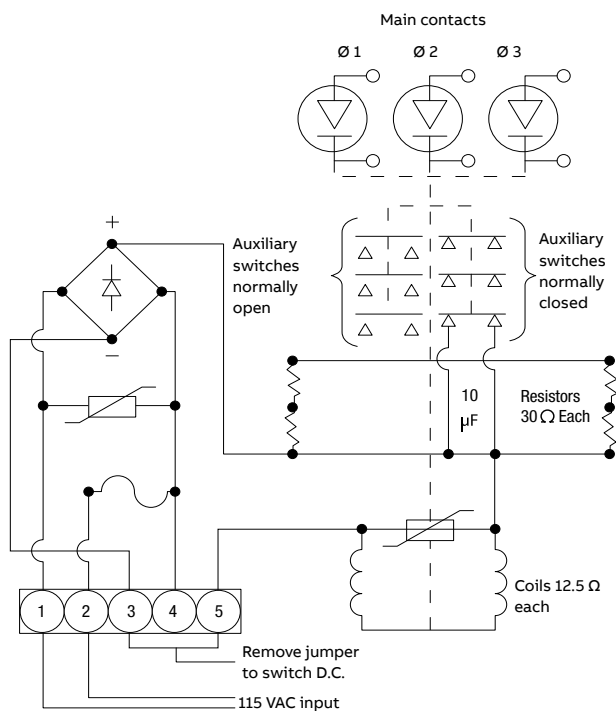


# Vacuum contactors

## RP133 three-phase vacuum contactors



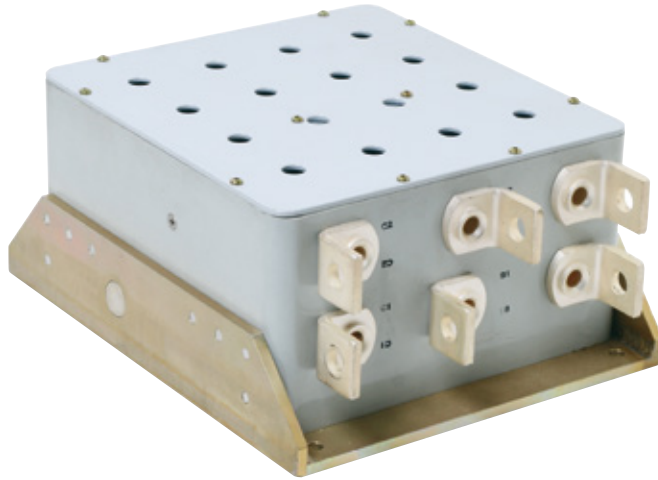
Units shown in de-energized position



<b>Voltage ratings</b>			
Maximum three-phase line (V and kV)	600 and 1.5		
Dielectrics 50/60/400 Hz, 60-second withstand			
— Line-to-ground (kV RMS)	6.5		
— Line-to-line (kV RMS)	6.5		
— Across open contacts (kV RMS)	6.5		
BIL, 1.2 x 50 μsec impulse			
— Line-to-ground peak (kV)	20		
— Line-to-line peak (kV)	20		
— Across open contacts (kV)	20		
<b>Current rating</b>			
Continuous (amps RMS)	450		
Load-switching (amps RMS)	450		
— Capacitors	750 kVAR @ 1.5 kV		
— Motors	750 HP @ 1.1 kV		
Making current (random make)			
— 100 times @ 1.5 kV with 3-second backup (kA RMS)	4.5		
— 10 times @ 1.5 kV with current-limiting fuse (kA)	28 peak		
— 100 times @ 1.5 kV with 3-second backup (kA RMS)	6		
Minimum load life @ 450 amps RMS	1 million open/close operations		
Interrupt (amps RMS @ 1.5 kV)	4500		
<b>Actuator</b>			
Control voltage	115 VAC, 50/60 Hz or 110 VDC		
Control current	7.1 pull-in amps, 0.9 hold-in amps		
Auxiliary contacts configuration	2 N/C, 3 N/O, SPST double break, 10 amps resistive @ 600 VAC		
<b>Mechanical</b>			
Weight (lb.)	30 max.		
Release time (msec.) from control switch off to separation of main contacts	16 max.		
Mounting	Operates in any position		
<b>RP133 three-phase vacuum contactors</b>			
Cat. no.	Mounting option	Actuator volts	Line-to-line voltage (RMS)
RP133-2332-00	2332	115 VAC/110 VDC	1500
RP133-2332-01	2332	115 VAC/110 VDC	3300
RP133-2334-00	2334	100 VDC	1500
RP133-2335-00	2335	115 VAC/110 VDC	1500

# Vacuum contactors

## RP151B three-phase vacuum contactors



Mechanically shock-hardened version available as shown

The Jennings RP151B three-phase vacuum contactor is a compact, normally open, three-phase device for use in equipment that requires a high-speed interrupt. It is useful as an overload interrupter to 2000 amps RMS interrupting capacity. Special erosion-resistant contacts provide an operational load life of 250,000 maintenance-free operations at the rated 200 amp current.

### Features

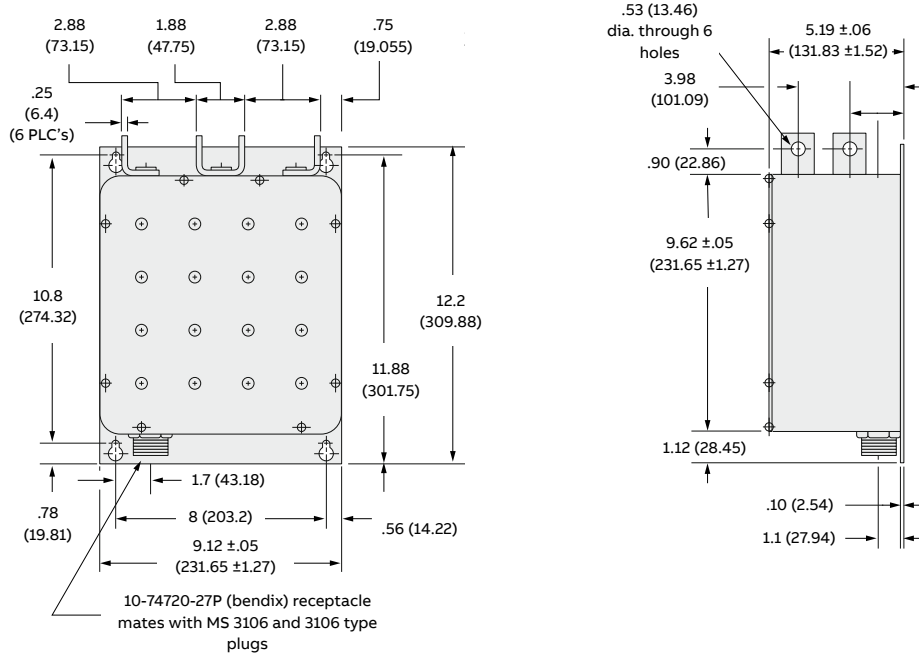
- Erosion-resistant contacts provide a minimum of 250,000 operations for long, maintenance-free life
- 2000 amps RMS interrupting capacity — ideal for use in an overload interrupter
- Three-phase, normally open operation provides high-speed interrupt

Voltage ratings	
50/60/400 Hz (V)	600
Current rating	
Continuous (amps RMS)	200
Maximum interrupting current (amps)	2000
Minimum load life	250,000 operations
Interrupt	Less than 2 cycles
Auxiliary contacts configuration	DPDT, 115/230 VAC, 8 amps

RP151B three-phase vacuum contactors					
Cat. no.	Mounting option	Voltage	Pull-in current (amps)	Hold current (amps)	
RP151B4541X44R20	4541	26.5 VDC	4.0	0.40	
RP151B4541X46R20	4541	100 VDC	1.5	0.05	
RP151B4541X47R20	4541	115 VAC	1.5	0.05	
RP151B4541X4XR20	4541	50 VDC	2.1	0.17	

# Vacuum contactors

## RP151B three-phase vacuum contactors



Units shown in de-energized position

