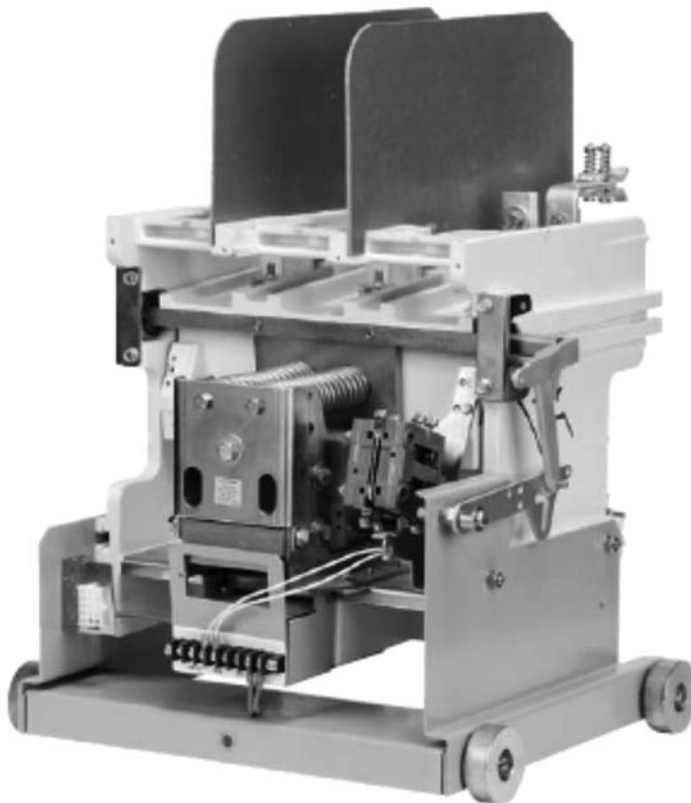


Instructions for installation, operation, and maintenance of the SL 15 kV, 300A vacuum contactor



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⚠ DANGER

HAZARDOUS VOLTAGE. READ AND UNDERSTAND THESE INSTRUCTIONS BEFORE ATTEMPTING ANY INSTALLATION, OPERATION, OR MAINTENANCE OF THE SL VACUUM CONTACTOR. RETAIN THIS DOCUMENT FOR FUTURE USE. THIS EQUIPMENT SHALL BE INSTALLED AND SERVICED ONLY BY QUALIFIED ELECTRICAL PERSONNEL. A QUALIFIED PERSON IS ONE WHO IS FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND WHO IS AWARE OF THE HAZARDS INVOLVED.



Powering Business Worldwide

Description

The SL vacuum contactor is a 15 kV, 300A contactor designed for starting and controlling three-phase, 50 or 60 Hz AC motors. Horsepower ratings are shown in **Table 1**. Motor full load current should not exceed the contactor current rating.

The short-circuit capacity of the power system may exceed the interrupting capacity of the contactor. The contactor should have short-circuit protection with current-limiting fuses as specified for the application. Substitute fuses should not be used without proper authorization by the factory. Ratings for the contactor are shown in **Table 2**.

Table 1. Application Data

System Voltage	Horsepower Ratings			Transformer, kVA	Interrupting Capacity in a Coordinated Starter, kA	
	Synchronous Motor		Induction Motor		Unfused NEMA Class E1	Fused NEMA Class E2
	1.0 PF	0.8 PF				
10,000–11,000	6750	6000	6000	5400 at 11 kV	5	63
12,400–13,800	8500	7500	7500	6800 at 13.8 kV	5	63

Table 2. Ratings

Description	Rating		Description	Rating	
Maximum interrupting current (three operations)	5000A		Control voltages	AC	110/120V, 220/240V, 50/60 Hz
Rated current	300A			DC	125V
Maximum rated voltage	15,000V		Control circuit burden (rated volt)	Closing	2600 VA
Making/breaking capacity	AC3–Make	3200A		Holding	80 VA
	AC3–Break	2560A	Auxiliary contact rating	Voltage (maximum)	600V
Short time current	30 seconds	1920A		Continuous current	10A
	1 second	4800A		Making capacity (AC)	7200 VA
	8.75 milliseconds	25 kA peak		Making capacity (DC)	200 VA
Mechanical life	1 million operations			Breaking capacity (AC)	720 VA
Electrical life	100,000 operations			Breaking capacity (DC)	200 VA
BIL	75 kV		Latch (when specified)	Mechanical life	250,000 operations
Dielectric strength (60 Hz)	36 kV (1 minute)			Trip voltages (DC)	24/48/96V
Closing time	80 milliseconds			Trip voltages (AC)	110/220V (50/60 Hz)
Opening times	50 to 330 milliseconds DIP switch selectable, refer to Table 4			Minimum trip voltage	80% rated coil voltage
Arcing time	12 milliseconds (3/4 cycle) or less			Trip burden 24 Vdc	1200 VA
Pickup voltage	80% rated coil voltage			48 and 96 Vdc	400 VA
Dropout voltage	60% rated coil voltage		110 and 220 Vac	500 VA	

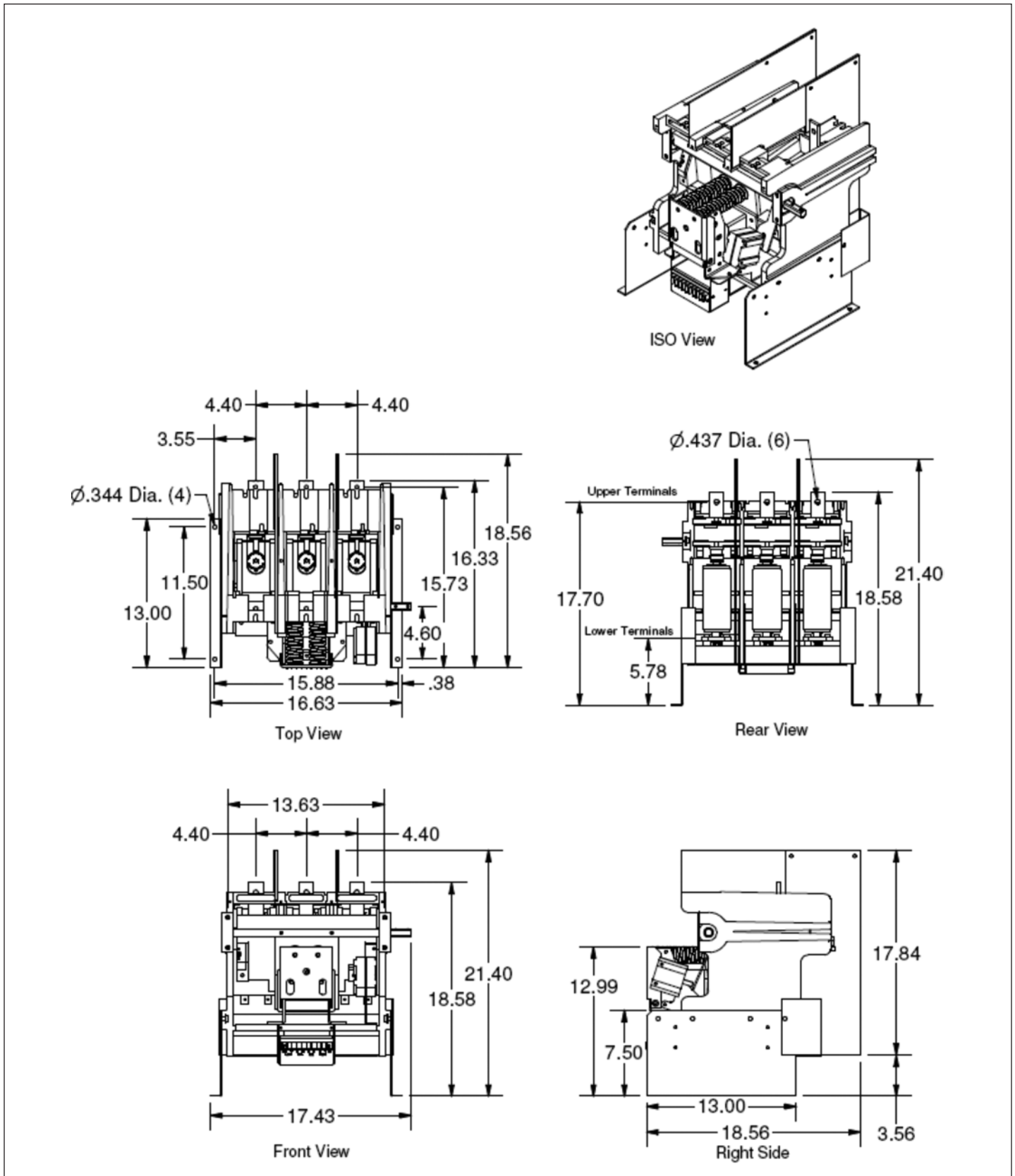


Figure 1. Outline and Mounting Dimensions

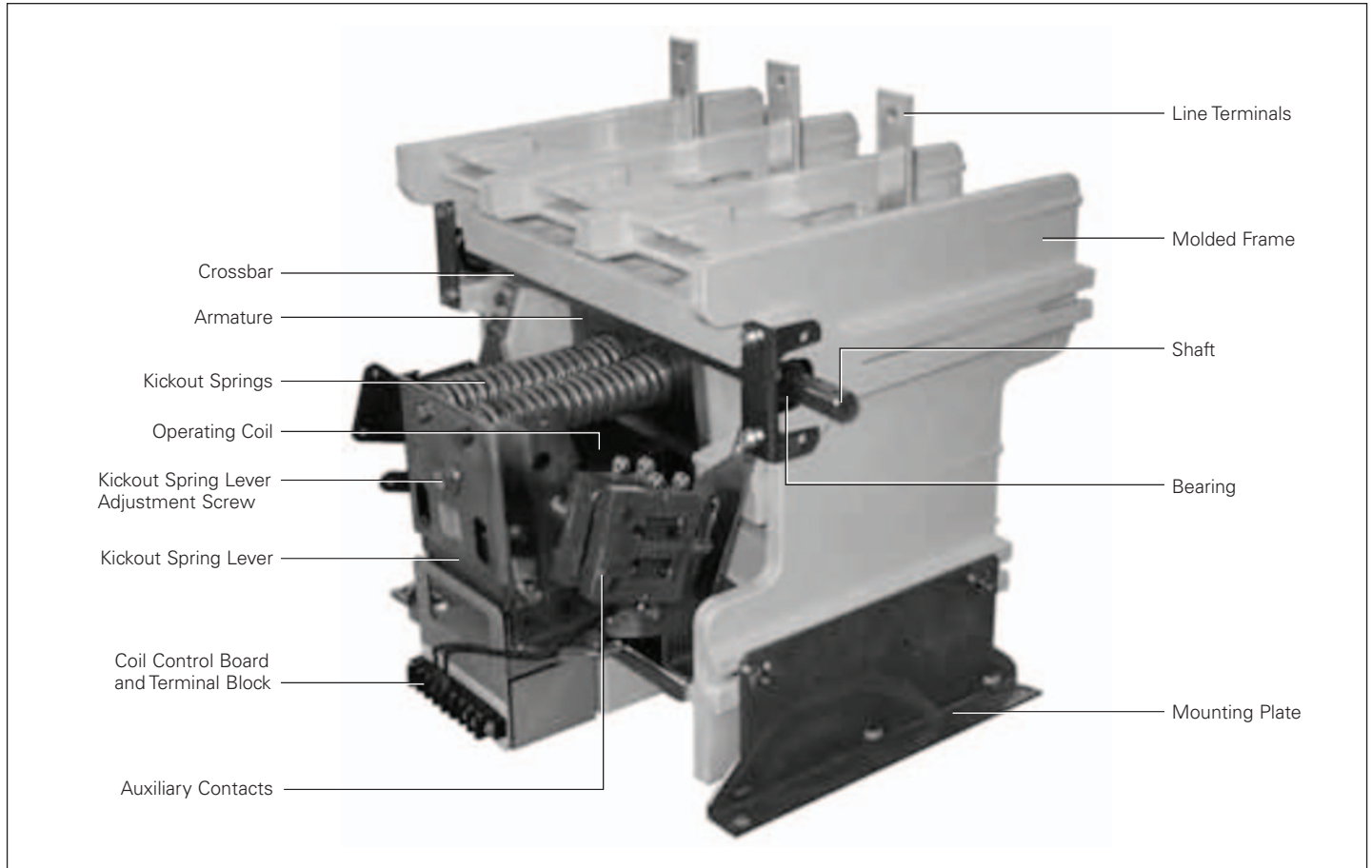


Figure 2. Front View Major Components

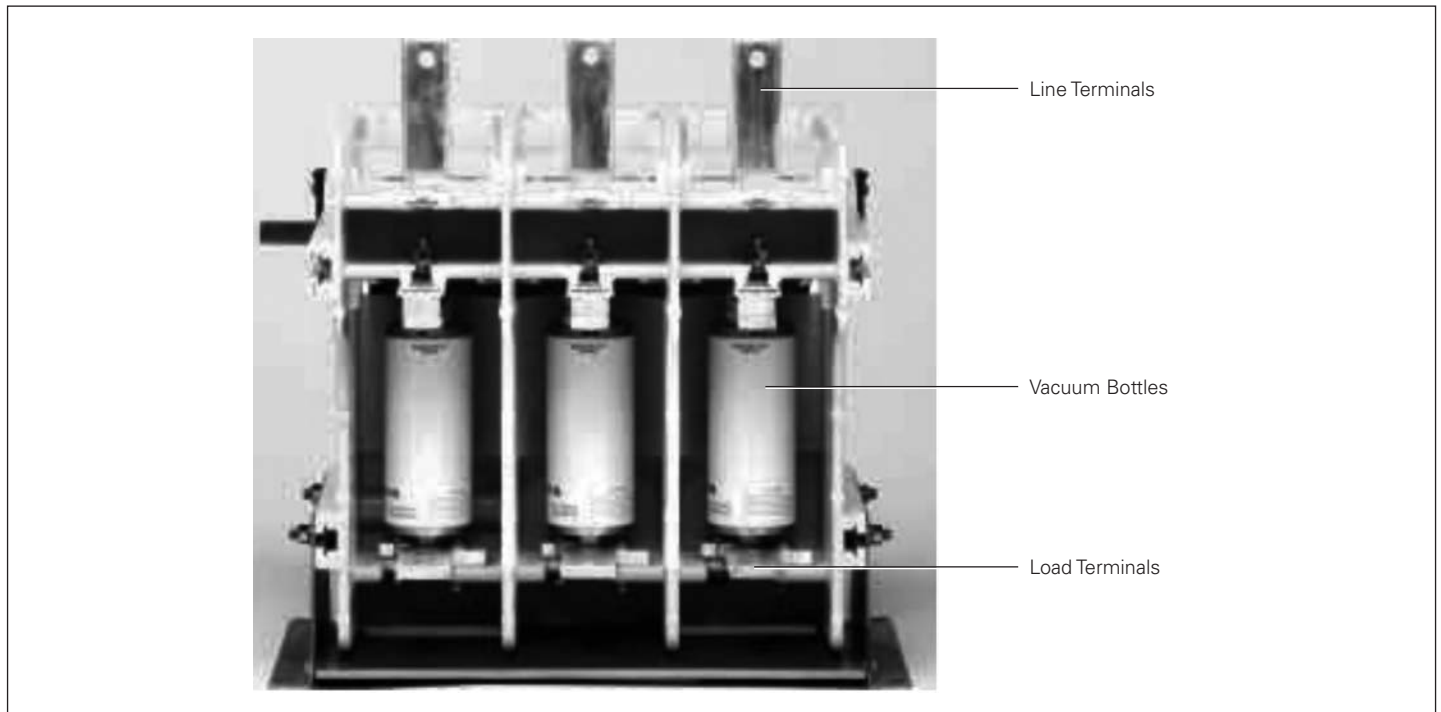


Figure 3. Rear View Major Components

Installation

⚠ DANGER

ALL WORK PERFORMED ON THIS CONTACTOR SHOULD BE DONE WITH THE MAIN DISCONNECT DEVICE OPEN AND LOCKED OUT. AS WITH ANY CONTACTOR OF THIS VOLTAGE, THERE IS DANGER OF ELECTROCUTION AND/OR SEVERE BURNS. MAKE CERTAIN THAT POWER IS OFF. CHECK FOR VOLTAGE WITH A VOLTAGE SENSOR OR A METER OF THE APPROPRIATE RANGE. MAKE CERTAIN THAT ALL TRANSFORMERS ARE ISOLATED TO PREVENT FEEDBACK AND THE RESULTANT GENERATION OF HIGH VOLTAGE.

The SL contactor weighs about 95 pounds. It should be handled gently to avoid damage to the vacuum bottles and factory adjustments.

The contactor is designed to be mounted in a medium voltage starter with overload relays and power fuses. In a factory assembled starter, the contactor is ready for service except for routine check-out as described in the **Initial setup** section.

The contactor should be mounted inside an enclosure that protects the unit from adverse environments such as dust and water. The mounting surface should be flat and horizontal, with provision for securely bolting the contactor in place with four 5/16-inch x 18 bolts. The mounting holes are located in side panels on the contactor as shown in the top view in **Figure 1**.

Contactor operation

The SL contactor has its main contacts sealed inside ceramic tubes from which all air has been evacuated, i.e., the contacts are in vacuum. The arc simply stops when the current goes through zero as it alternates at line frequency. The arc usually does not survive beyond the first half cycle after the contacts begin to separate. The ceramic tube with the moving and stationary contacts enclosed is called a vacuum interrupter or a vacuum bottle and there is one such bottle for each pole of the contactor. A metal bellows (like a small, circular accordion) allows the moving contact to be closed and pulled open from the outside without letting air into the vacuum chamber of the bottle.

The moving contacts are driven by a molded plastic crossbar rotating with a square steel shaft supported by two shielded, pre-lubricated ball bearings that are clamped in true alignment for long life and free motion. See **Figure 2**. Only the end edges of the square shaft are rounded to fit the bearings, so that portions of the four shaft flats go through the bearings for positive indexing of the mechanical safety interlocks.

The contacts in an un-mounted vacuum bottle are normally closed, because the outside air pressure pushes against the flexible bellows. For contactor duty, the contacts must be open when the operating magnet is not energized. Therefore, the contacts of the vacuum bottles must be held apart mechanically against the air pressure when used in a contactor. In the SL contactor, all of the bottles are held open by two kickout springs on the front of the contactor. See **Figure 2**. The kickout springs press against the moving armature and crossbar and thereby force the bottles into the open contact position. Note that in the open position, the crossbar is pulling the moving contacts to hold them open.

Up to an altitude of 3300 feet, the contactor is designed to tolerate normal variations in barometric pressure.

The contact force at sea level when fully closed is intended to be 65 to 75 pounds. This will decrease approximately 0.75 pounds per 1000 feet above sea level. If the contact force is below 65 pounds, contact the factory.

The contactor is closed by energizing the contactor control board with the appropriate control voltage at terminals 1 and 2. The control board rectifies the input voltage and applies a pulse width modulated DC output voltage to the coil. The output voltage is approximately full voltage for the first 200 milliseconds after energization, during which time the contactor closes and seals. The output voltage is then automatically reduced to approximately 15 Vdc to maintain the contactor in the closed position.

The coil core is magnetized, which rotates the armature shaft, armature, and crossbar. As the armature moves toward the coil core, the main contacts close. The crossbar continues to move an additional distance (known as overtravel), which allows for contact preload and wear. The overtravel distance is the gap between the lower bottle nut and the pivot plate as shown in **Figure 4**.

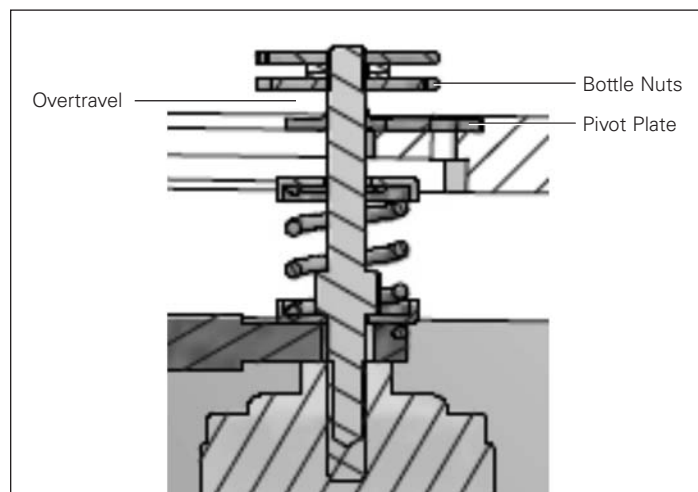


Figure 4. Closed Contactor

When control power is removed from the control board, the contactor is held closed for a preset time and then opens. The range of time between the removal of control power and contact opening is from 50 to 330 milliseconds. The time can be adjusted for such factors as fuse coordination and voltage loss ride-through. Unless otherwise specified, the factory default dropout setting is 130 milliseconds, or approximately 8 line cycles (60 Hz).

A selectable DIP switch for setting the control voltage level and the contactor dropout time is located on the control board. See **Figure 5**. The control board must be removed from the cavity in the contactor housing to gain access to the DIP switch. **Table 3** lists the available voltage settings and **Table 4** lists the available dropout settings. These tables are also printed on the back of the control board.

Table 3. DIP Switch Setting Control Voltage

Setting	SW1	SW2	SW3
110 Vac, 50 Hz	Off	Off	Off
120 Vac, 60 Hz	On	Off	Off
220 Vac, 50 Hz	Off	On	Off
240 Vac, 60 Hz	On	On	Off
125 Vdc	Off	Off	On

Table 4. Control Board Dropout Settings

Delay Setting	SW4	SW5	SW6
50 ms	On	Off	Off
130 ms	Off	On	Off
250 ms	On	On	Off
330 ms	Off	Off	On

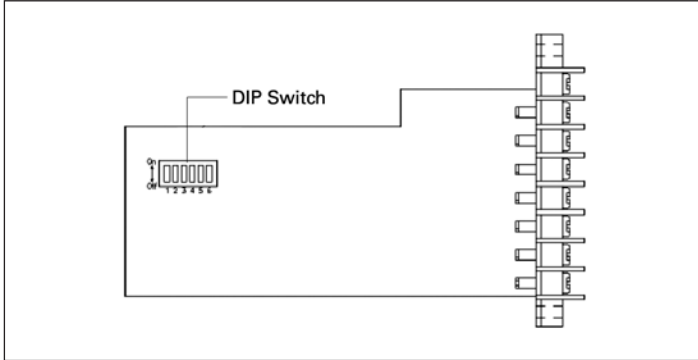


Figure 5. Coil Control Board with DIP Switch

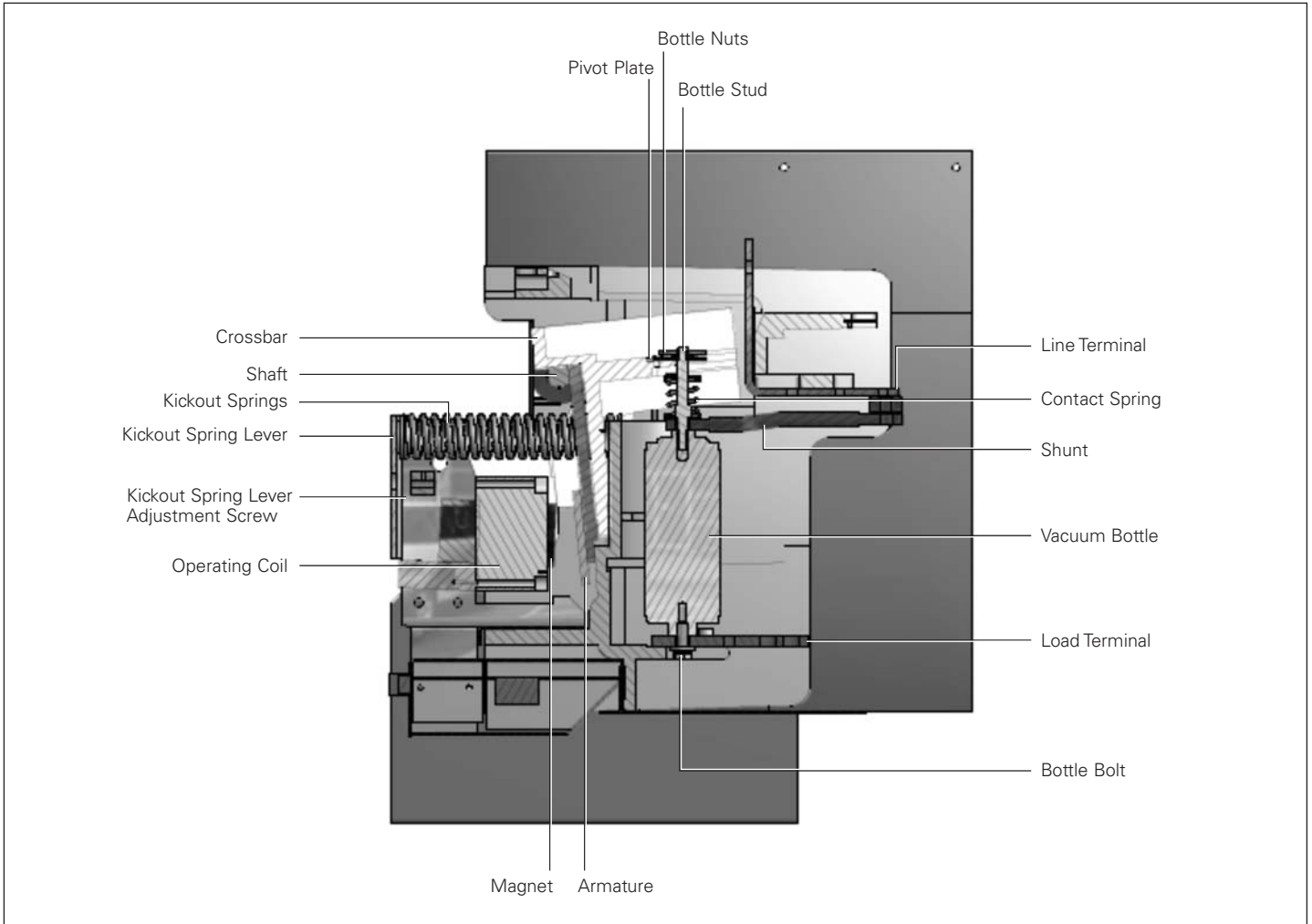


Figure 6. Open Contactor

Wiring

Refer to **Figure 7** for standard control wiring for magnetically held contactors. To close the contactor, apply power to terminals 1 and 2 on the control board. Power must be maintained to terminals 1 and 2 to keep the contactor in the closed position. The coil is connected to terminals 5 and 6.

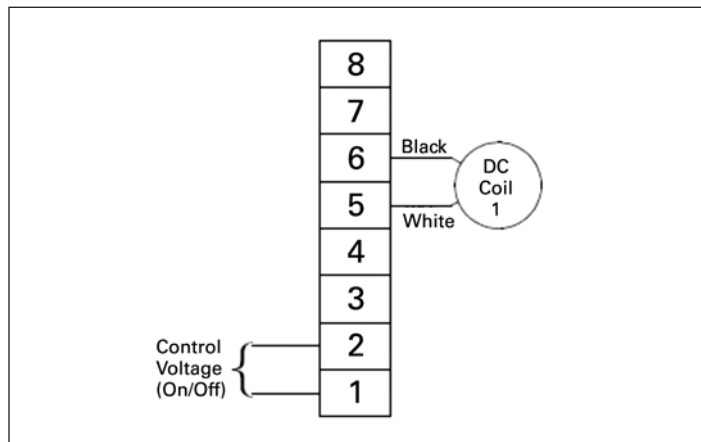


Figure 7. Connections for Magnetically Held Contactor

Initial setup

Check-out, mechanical

Verify that all power circuits are de-energized and/or isolated. The contactor can be checked in its cell or outside. If the starter is a new factory assembly, it is probably easiest to test the contactor as installed. Any mechanical interlocks must be checked as installed, to make certain that safety interlocks function properly.

If the contactor is checked in its cabinet, verify that the contactor coil is electrically isolated, to prevent feedback into a control transformer that could be hazardous.

With an extension cord and a separate power source of correct AC voltage, connect power to the control board of the contactor. Operate the appropriate pushbuttons to close and open the contactor, and to check out the sequence. If the contactor does not close fully or does not drop out fully, refer to **Magnet operating range** in the **Maintenance** section.

When the contactor is closed, observe the overtravel gap between the pivot plates on the crossbar and the underside of the lower bottle nut on each pole. This overtravel gap should be no less than 0.100-inch when the contactor is new.

When the contactor is open, the armature plate should be firmly seated against the contactor housing.

Disconnect extension cord and proceed with installation.

Check-out, vacuum interrupters

⚠ DANGER

THIS PROCEDURE REQUIRES THE USE OF A HIGH POTENTIAL TEST UNIT THAT PRODUCES HAZARDOUS VOLTAGES.

⚠ WARNING

APPLYING HIGH VOLTAGES ACROSS THE OPEN CONTACTS OF A VACUUM INTERRUPTER MAY PRODUCE X-RAYS. THE RADIATION MAY INCREASE WITH AN INCREASE IN THE VOLTAGE OR A DECREASE IN THE DISTANCE BETWEEN THE OPEN CONTACTS. THE LEVELS OF RADIATION GENERATED AT THE RECOMMENDED TEST VOLTAGES AND NORMAL CONTACTOR OPEN GAP SPACING ARE EXTREMELY LOW. HOWEVER, AS A PRECAUTIONARY MEASURE, IT IS RECOMMENDED THAT ALL OPERATING PERSONNEL STAND AT LEAST THREE FEET AWAY FROM THE CONTACTOR WHILE PERFORMING THIS TEST.

The dielectric strength of the interrupters should be checked before the contactor is energized for the first time and regularly thereafter to detect at the earliest possible date any deterioration in the dielectric strength of the contact gap because this may result in an interruption failure. Although an AC dielectric test is recommended, a DC test may be performed if only a DC test unit is available. A good interrupter will withstand a 36 kV–60 Hz test or a 50 kV–DC test across the open gap for one minute. When performing DC tests, the voltage should be raised to the test value in discrete steps and held for a period of one minute. Due to the high voltage levels required to conduct this test, it is recommended that the contactor be removed from the starter cell before beginning the test.

Check-out, insulation level

After installation and before energizing the contactor for the first time, the dielectric test levels between poles and from each pole to ground should be measured and recorded. Conduct testing at a value of two times the nominal voltage.

Maintenance

A maintenance program should be established as soon as the contactor is installed and put into operation. After the contactor has been inspected a number of times at monthly intervals, and the condition noted, the frequency of inspection can be increased or decreased to suit the conditions found, because this will depend upon the severity of the contactor duty. It is a matter of operator judgment.

All work on this contactor should be done with the main circuit disconnect device open and locked out, and by using a separate source of control power to operate the magnet. Before applying external control circuit power, verify that the contactor coil circuit is electrically isolated, to prevent feedback into a control transformer that could be hazardous. Disconnect power from any other external circuits.

Insulation level

The dielectric levels between poles and from each pole to ground should be measured regularly and recorded. Conduct testing at a value of two times the nominal voltage.

Dust and moisture are detrimental to electrical equipment and should be wiped or blown off at appropriate intervals. If the contactor is wet for any reason, it must be dried until insulation resistance between poles and from each pole to ground has returned to normal.

The contacts inside the interrupters are immune to dust and moisture and do not require this attention.

Vacuum interrupters

The dielectric strength of the vacuum interrupters should be tested on a periodic basis as specified in **Check-out, vacuum interrupters** in the **Initial setup** section.

The interval between periodic tests depends on the number of operations per day, environmental factors, and experience. Periodic dielectric tests across open contacts should not be omitted on the basis of satisfactory contactor performance, because under certain operating conditions, the contactor may perform satisfactorily even though one vacuum interrupter becomes defective.

Contact wear allowance

Contact material vaporizes from the contact faces during every interruption and condenses elsewhere inside the bottle. This is normal and is provided for by overtravel, or wear allowance. When the contactor is fully closed, there is a gap between the lower bottle nut and the pivot plate. See **Figure 4**. As the contacts wear, this gap decreases. When the gap goes below 0.071-inch on any pole, all the bottle subassemblies should be replaced. Use the 0.071-inch thick fork-shaped overtravel gauge supplied for this measurement, part number 151B591H01. **DO NOT READJUST THE BOTTLE NUTS TO RESET OVERTRAVEL AS THE CONTACTS WEAR.** When placed into service, overtravel should be checked, but not adjusted.

Inspection after short circuit or overload

The contactor is intended to be protected by power fuses and/or a circuit breaker in accordance with the NEC®. However, the magnitude of a short circuit may exceed the damage threshold of the vacuum bottles. After the interruption of a short circuit, the unit should be examined for any apparent physical damage or deformation of conductor bars and cables. If there is any evidence of severe stress, it is recommended that the bottle subassemblies be replaced. If the overtravel has changed significantly (from the last inspection) on one or more bottles, all bottle subassemblies should be replaced.

A dielectric test would not by itself confirm that the bottles should be returned to service after a fault. However, if there is no physical evidence of stress, and if the overtravel exceeds the 0.071-inch minimum, the bottles can then be dielectrically tested as outlined previously. If physical stress, overtravel, and dielectric are within acceptable limits, it is reasonable to return the bottles to service after a fault.

If the contactor opens locked rotor current as a result of a relay tripping, the mechanical damage typical of a short circuit will not occur. However, the bottles should be dielectrically tested as outlined previously before returning to service.

Magnet operating range

When properly adjusted as described in previous sections, the contactor should operate within the ranges shown in **Table 5**.

Table 5. Coil Performance

Rated Coil Voltage	Pickup Voltage Below	Dropout Voltage Below
110–120 Vac	96	75
125 Vdc	100	82
220–240 Vac	192	150
250 Vdc	200	164

If the contactor does not operate within these ranges, look for mechanical interference that prevents the magnet from sealing. If there is no interference, then the magnet itself may be misaligned. The magnet gap can be seen from the left and right sides with the help of a flashlight. The stationary magnet can be aligned with a 1/2-inch diameter steel rod inserted into the two holes in the core of the magnet and used as a lever to put a corrective set into the magnet frame. It should not be necessary to do this unless the contactor has been damaged and it can be seen that the armature does not fit against the magnet. A poor magnet-to-armature fit usually produces a high dropout voltage and/or chatter.

Mechanical interference can be produced by various incorrect adjustments. Two specific points to check are as follows:

1. The armature travel is incorrect, causing the contact springs to be compressed into a solid, non-resilient “tube” that stops the crossbar rigidly. Call Eaton for assistance.
2. The auxiliary contact operating arms are misadjusted, so that an interlock plunger bottoms solidly before the magnet seals. When the contactor is fully sealed closed, there should still be a small amount of travel remaining for these plungers. Adjust as described on **Page 9**.

Auxiliary contacts

Two type L64 electrical interlocks are mounted on the front (right side) to provide four auxiliary, isolated 600V, 10A, double-break contacts for use in control circuits. Any combination of normally open or normally closed circuits is available by selection of the appropriate style of interlock assembly.

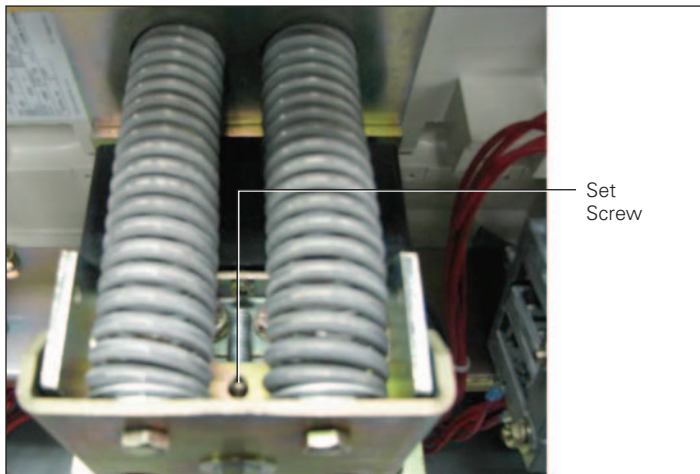
In the open position, the interlock plungers should rest lightly against the interlock operating arm. However, the interlocks should not bottom solidly in the closed contactor position.

Operating coil replacement

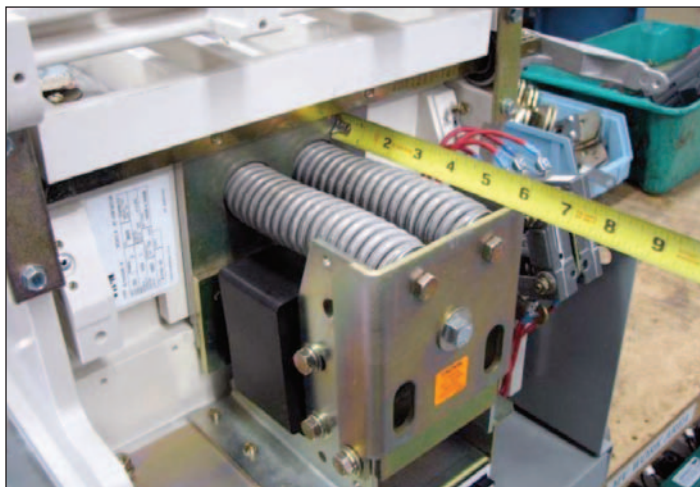
Reference **Figure 6**. Recommended tools for operating coil replacement are as follows:

- Flat screwdriver, at least 8 inches long
- 1/2-inch socket wrench with driver
- 9/16-inch socket
- 3/16-inch Allen wrench
- 1/2-inch open-end or ratchet wrench

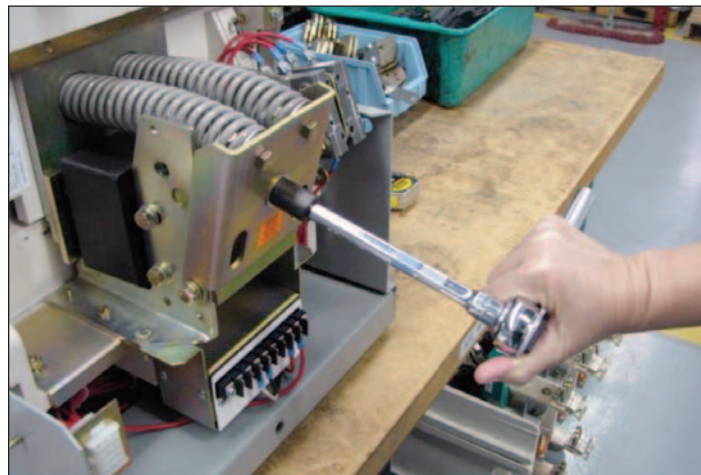
1. De-energize all circuits.
2. Loosen the set screw holding the kickout spring lever adjusting screw.



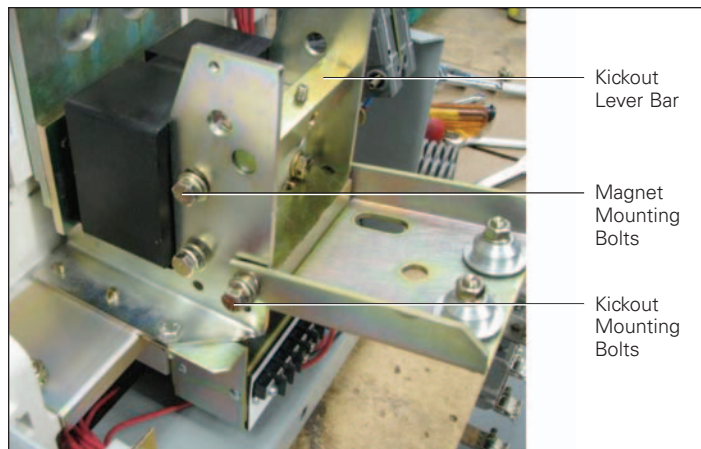
3. Measure the distance from kickout spring lever to armature and record.



4. Loosen the kickout spring lever adjusting screw until the kickout springs can be removed easily.



5. Remove leads from coil to terminals 5 and 6 on the control board. Refer to **Figure 7**.
6. Remove the four 5/16-inch magnet mounting bolts and set aside.



7. Loosen the kickout spring lever mounting bolts.
8. Remove kickout lever bar.
9. Remove entire coil assembly from contactor.
10. Remove the two 8-32 screws holding the coil and remove the coil from the assembly.
11. Install the new coil on the magnet assembly and replace the two 8-32 screws previously removed.
12. Place the coil assembly into the contactor.
13. Replace the kickout lever bar.
14. Replace the four 5/16-inch mounting bolts previously removed. Do not tighten bolts.
15. Reconnect the coil wire to the control board.
16. After checking for safety, energize the coil and close the contactor.

Note: Whenever adjusting the kickout spring lever, put your free hand over the kickout springs as a precaution.

17. Reinstall the kickout springs, making sure to put the two ends of the spring wire downward, so that the springs will take a natural bow. Tighten the adjusting screw until the distance from the kickout spring lever to the armature is equal to the measurement recorded in step 3. Tighten set screw to lock the kickout spring lever adjusting screw.
18. Visually inspect the coil. With the contactor still closed, the coil should be flush with the armature and be upright. If not, adjust the top two 5/16-inch magnet mounting bolts as required to align the coil. Tighten all six 5/16-inch mounting bolts when the coil has been adjusted properly.

Vacuum bottle replacement

If the vacuum interrupters fail the vacuum integrity or wear check, or if they have more than 300,000 operations, they must be replaced. The three interrupters must be replaced as a set.

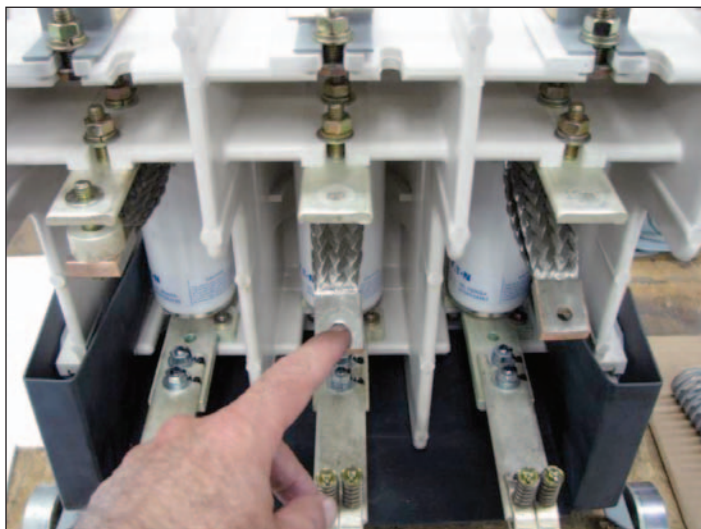
⚠ CAUTION

THERE ARE BELLOWS IN EACH INTERRUPTER THAT SEAL THE MOVING CONTACT FROM THE ATMOSPHERE. THESE BELLOWS ARE FRAGILE AND MUST BE PROTECTED FROM ANY TORSIONAL LOADING. AN APPROPRIATE TOOL MUST SUPPORT THE MACHINED FLATS ON EACH END OF THE INTERRUPTER WHEN TIGHTENING ANY HARDWARE ON THE INTERRUPTER. BOTTLE WRENCH, EATON PART NUMBER 4A36081H01, IS PROVIDED WITH EACH SET OF REPLACEMENT VI'S AND SHOULD BE USED IN THIS APPLICATION.

Reference **Figure 6**. Recommended tools for vacuum bottle replacement are as follows:

- Flat screwdriver, at least 8 inches long
- 1/2-inch socket wrench with driver
- 3/16-inch Allen wrench
- 1/2-inch open-end or ratchet wrench

1. De-energize the contactor. Remove the barrier assembly.
2. Unbolt the shunts on the line side of the bottles.



3. Remove the bottle nuts from the top stems, using a screwdriver to unlock. Set aside the screws, nuts, and washers.



4. Remove the two 5/16-inch mounting bolts that attach each bottle subassembly. Set bolts aside.
5. Withdraw the bottle subassemblies from the contactor chassis, pulling the bottom end out first so that the top stud clears the rear of the chassis. The contact springs are loose at this point and should be captured and set aside. The bottle subassembly consists of the bottle, shunt, and related hardware.
6. Loosen and remove the bottle bolt that holds the copper conductor to the bottle. Retain the shim from under the copper conductor and the copper spacer.

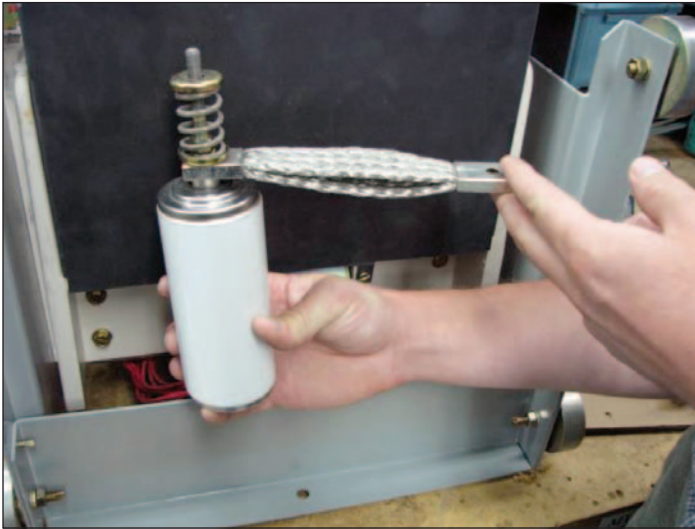
⚠ CAUTION

AT NO TIME DURING THE INSTALLATION OF THE NEW BOTTLE SHOULD TORQUE BE APPLIED TO THE MOVABLE END OF THE VACUUM BOTTLE. INTERNAL DAMAGE MAY RESULT IF THIS OCCURS.

The used vacuum bottles should be destroyed. Destroying the vacuum bottles will ensure that they are not later considered new and installed in another contactor.

7. Fasten the removed copper conductor to the new bottle with the shim between the mold frame and the copper conductor, and the bottle spacer between the bottle and the copper conductor. Do not tighten the bolt at this time.
8. Preset the shunt by bending the free end in a smooth curve to touch the stud, then release.

9. Install contact springs and cups onto the top stems, with cup on top, flange down.



10. Insert bottle subassemblies into chassis, putting top end in first and guiding the bottle stud into the slot in the crossbar. Check to verify that the spring and cup are between the bottle and the crossbar.
11. Bolt the subassemblies into the chassis, using the 5/16-inch bolts, two per pole.
12. Align the bottle on the bottle mounting (the bottle bolt is loose) until the stud does not rub or touch the slot in the crossbar. Tighten the bottle bolt. Check alignment again to verify that it was maintained while tightening.
13. Attach shunts to line side.
14. Recheck to verify that the bottle studs remain clear of crossbar slots. In particular, confirm that the shunts have a slight bow downward and do not push the bottle studs against the crossbar slots. If they do push the studs, loosen the shunts from the line terminals and repeat step 10.
15. Close the contactor by applying rated voltage from an isolated power source, using adequate care against electrical shock. The contactor can also be closed mechanically by hand, using the yoke interlock.
16. Install two bottle nuts, plus the two flat washers previously removed, onto the center pole bottle stud. Both bottle nuts MUST have their threaded flanges facing up, on top.
17. Turn the center pole bottle nuts clockwise until they are 0.100 +/-0.005-inch from the pivot plate. This is the overtravel gap setting. See **Figure 4**. Lock the bottle nuts with a screwdriver inserted from the front of the frame molding, turning the screwdriver counterclockwise with the blade fitted from a notch in one bottle nut across to a notch of the other bottle nut.
18. De-energize the coil and remove the extension cord.
19. Loosen the set screw holding the kickout spring lever adjusting screw.
20. Measure the distance from kickout spring lever to armature and record.
21. Loosen the kickout spring lever adjusting screw until the contacts on the center pole barely touch, using a volt-ohmmeter or a low voltage test light as an indicator of touch and then open.
22. With the contactor in this position, install and adjust the bottle nuts (and spacing washers) on the two other poles so that these two poles make contact simultaneously with the center pole when checked with a volt-ohmmeter or a test lamp circuit. Lock the bottle nuts with a screwdriver as done before.
Note: Whenever adjusting the kickout spring lever, put your free hand over the kickout springs as a precaution.
23. Tighten the kickout spring lever adjusting screw until the distance from the kickout spring lever to the armature is equal to the measurement recorded in step 20. The armature should be firmly seated against the contactor housing. Tighten the set screw to lock the kickout spring lever adjusting screw.
24. Reinstall the barrier assembly.

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