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Safety Considerations When Using Vacuum Circuit Breakers or Fused Vacuum Starter

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Safety Considerations When Using Vacuum Circuit Breakers or Fused Vacuum Starters

This discussion will review applications on low voltages, 600V or less, and medium voltage, 2000V-7200V involving vacuum interrupter type designs.

The advantages of interrupting an electric current in a vacuum have been well documented since this technology was introduced in the mid 60's. This technology has proven its worth over the decades.

It is worth comparing a vacuum interrupter used as a fault interrupting circuit breaker and a fused vacuum contactor. The vacuum circuit breaker designed to interrupt high currents 25-40ka infrequently. The fused vacuum contactor designed to switch motor, transformer or capacitor loads usually less than 4ka, frequently.

The advantages are similar for both low and medium voltage applications. However, the benefits and cost savings are greater for the medium voltage applications.

Safety

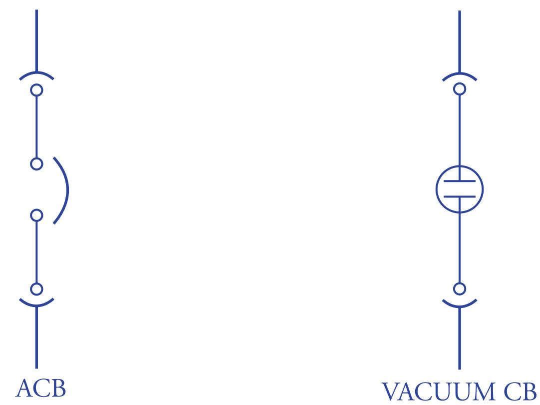
Safety is always an issue and both low and medium voltage potentials are extremely dangerous and must be respected by those who service and maintain this type of equipment. In an application where we supply vacuum contactors for electrified prison fences, the potential is 5.0kv with 64m A of current "enough to kill", this is 320va. A typical industrial system can have a fault current at 4.16kv of 350-400 MVA (million volt amps). It can and will jump out and get you. You should insist on equipment that offers "visible gap" isolation viewing windows.

Safety isolation

Safety isolation distances are important and that one recognizes the difference here to electrical isolation. It's important to recognize that if something fails, it fails safely and safety isolation and distance is not compromised.

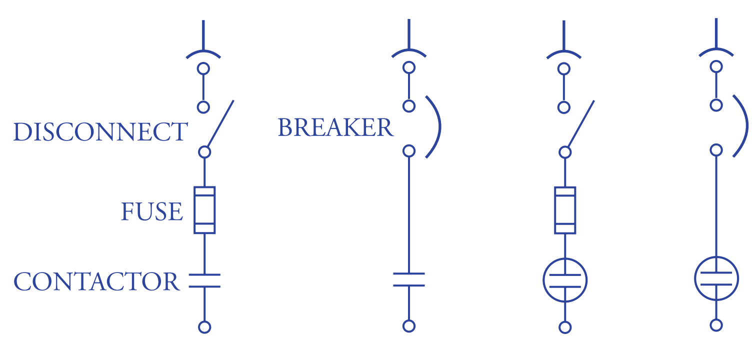
Isolation methods for vacuum circuit breakers and vacuum contactors/starters are different for both low and medium voltage systems, some of which goes back to historical practices applied when air gap technology was applied. Vacuum interrupter gaps are typically 0.080”-0.75” for electrical isolation but these are not safety gaps and they cannot be seen (visible).

Low or medium voltage drawout circuit breakers



Simple single line circuit for air and vacuum draw-out low or medium voltage circuit breakers.

Low voltage MCC drawout buckets

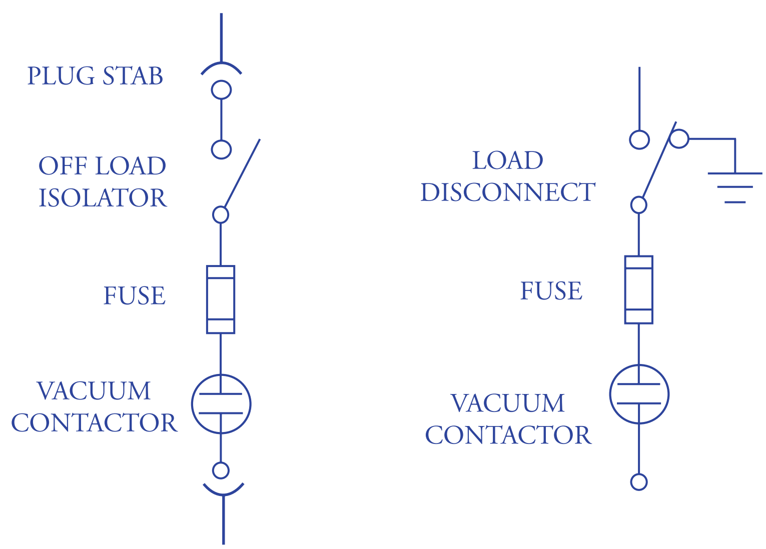


Simple single line circuit for air break contactor and vacuum contactor in low voltage draw-out MCC buckets.

In circuit breaker example, both air and vacuum designs do not have back up disconnect switches that ensure safety isolation in the event of a failure to interrupt. If this happens, the devices are likely to disappear rapidly and violently in both low and medium voltage applications. One must also consider that loss of vacuum in the vacuum circuit breaker may allow draw-out or plug in action thus allowing an off load mechanism to become “on load”. This is a serious and dangerous condition!!

The fused or circuit breaker protected air or vacuum starters in a low voltage MCC are both protected in a situation of a contactor failing to interrupt or welding closed. Ultimately, so long as a visible load break disconnect is applied as with the fused switch design, then drawing out on load should be prevented. However, if the circuit breaker should fail, then because of no visible isolation gap, it leaves the off load system vulnerable to draw-out/pluggable on load operations.

Medium voltage drawout vs fixed design



Simple single line diagram for medium voltage fuse vacuum starter draw-out vs. fixed.

It has been long practiced and promoted as an excellent engineering practice to vack up an air or vacuum contactor in low voltage MCC whether they are a fixed or draw-out design's. Safety belt and suspender built in.

One would think therefore, we would practice the same at medium voltage, not so the circuit shown on left here is typical of most medium voltage manufacturers' draw out designs. The safer fixed style shown on the right is offered by few manufacturers.

Essentially a design using off or no-load isolation does not fail safe which is a lousy engineering principle. The National Standard Organization and safety organizations are aware of these short comings. So how did this situation develop where equipment does not fail safely?

One has to go back to air break contactor technology which has designed as draw-out equipment with off load isolation or switches (the use of MV circuit breakers makes the coat and size prohibitive.)

Draw-out interlocks worked in conjunction with off load isolators or draw-out mechanisms tied to the position of the air break contactor magnetic armature position. This to a degree was somewhat but not totally secure. If an air break contactor failed, it usually would fail on closing and contact weld closed. The interlock would detect this and not allow any disconnect or draw-out to occur.

The scenario with failure of a vacuum contactor is usually the opposite of its air-break counterpart. A vacuum contactor fails in the open position where now such interlock designs do allow an off/no-load isolator to attempt to switch high load currents. This is where the "jump out and get you" part happens. Off or no-load isolators do not protect you if you close on to a fault. So why would you do that? Those who do, likely never know they did, or lived to tell about it.

A typical scenario, a load (motor) trips and it's determined a fuse has blown; it transpires two fuses had blown; the electrician isolates the circuit and replaces the fuses. They should check why the fuses had blown. Too often assumptions are made that fuses had pre-aged, not so in this case, a cable fault has developed. The through fault current also degraded the vacuum interrupter causing a contaminated or gassy interrupter. This should also be checked after a fault or fuse blowing occurrence. As in any disaster a sequence of tragic steps occur. This is no exception. "Let's replace the fuses and try again". As the units are plugged back in or the off/no-load isolator closed, the fault currents run again. This time the unit is not fully closed and arcing fault current and gasses flow. The result is catastrophic failure and likely serious injury or death to the operator.

If a vacuum contactor loosens vacuum a similar scenario occurs in reverse as attempts are made to open with load current flowing, this generates a gaseous fault.

In both of the above situations, the fault area is on the unprotected side, on the line side of the branch circuit, fuses, so full, fault currents can be sustained for several cycles before upstream protection can react. A failure of procedures or equipment failure occurs, the system had no backup; therefore, it did not fail safely.

Non of us want to see people hurt or killed and training programs now matter, how intense can never be fully protective. "If they can they will" take short cuts and forget procedures. The equipment designs should be such that such short cuts are mechanically or electrically checked such that the operator is aware the "short cut" is not allowed.

I described the designs used in Low Voltage Motor Control Centers and Medium Voltage Starters and some design buckets that incorporate backup fault making, load breaking disconnect switches. The deadly scenarios described earlier would have been prevented had equipment with fault make load break switches been specified and selected.

You owe it to the safety of your personnel, your reputation, and your company's reputation to buy the safest equipment possible or if you consider draw-out equipment with off load isolation, ask the manufacturer how he protects against the described failure modes. You will hear stuttering or foot shuffling or both.

You don't need to be told that it's up to your training procedure. There is an option. Fixed style designs, incorporating fault make/load break switches, are available competitively priced with many other safety features. They are also compact and have all the advantages vacuum technology offers.

John Lett became involved with vacuum power switching in the early 1960s, soon after completing his engineering studies at Aston University in his native UK. Working on Low and Medium Voltage Contactor and Motor Control Center designs, Lett's work in Engineering, Sales and Product Management developed competitive vacuum designs and expanded their acceptance in European markets. In 1978, he moved to the United States to continue this work in North America, where at the time few manufacturers of vacuum power products existed.

Vacuum designs are extensively used today, and at medium voltage almost exclusively used in power switching for motors, transformers and capacitors.

Lett retired from JCC/Danaher in 2009, but still works as a consultant for the company. He considers the next step for vacuum products to be utilized in the 10-15 Kv ranges as new motor designs are developed.