Product Data

Subject A COMPARISON OF AIR BREAK CONTACTORS AND AIR BREAK CIRCUIT BREAKERS FOR HIGH VOLTAGE APPLICATIONS

File 8110

Quite often there is a strong tendancy to apply contactors for circuit breaker applications and circuit breakers for contactor applications. In special cases, this may be justified if a complete study of the application indicates economic advantages can be obtained without sacrificing performance or preferred engineering methods. Sometimes, there is no recourse but to apply one for the other's application.

High voltage contactors and high voltage circuit breakers differ in many respects. One distinguishing feature is the manner in which they function. Contactors are magnetically held in their normal operating position. Circuit breakers are mechanically held. This is characteristic of both oil immersed and air break equipment. Although the comparisons in this article consider air break designs only, much of the discussion applies to oil immersed designs as well.

The art of high voltage circuit breaker design is much older than that of high voltage contactors. High voltage air break contactors are relatively new and at one time, circuit breakers were the only devices available for high voltage switching, whether it was for feeder disconnects, transformer disconnects, or motor starters.

As industry expanded and large steam drives were replaced with high voltage electric drives, it became apparent that circuit breakers were not always adequate for controlling motor applications. Oil immersed high voltage contactors were developed to perform more in line with motor control requirements. Oil immersed contactors were developed first because it was much easier to extinguish an arc under oil at that time. As the demand grew and better materials became available, air break contactors were developed.

Throughout the years, circuit breakers and contactors have been continually modified and improved, the manufacturers always striving for a maximum in performance and economy. As a result, both types of equipment are designed with specific characteristics for their particular application. A contactor is predominately a motor controlling device, and a circuit breaker is predominately a circuit interrupter and protective device. The high voltage contactors and circuit breakers marketed today are highly engineered devices, each having a definite purpose.

A few outstanding examples of one device being used for the other's application are discussed below.

A. Circuit breakers are used in place of contactors for motor starters where voltages or currents are higher than the rating of high voltage contactors. 5000 volts and 400 amps is the highest rating for contactors as defined by

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NEMA standards. Some 6900 volt contactors have been applied for limited service. Special contactors rated above 400 amps may be encountered also.

B. Circuit breakers are used in place of contactors for motor starters where the starting duty is very infrequent. This would be in the order of a few times in months. In this case, it is desired to use equipment for motor control and branch circuit disconnecting and protection in a single device. Space and economics may be the deciding factor. This is usually an advantage only when there is a single motor starting device required on a branch circuit.

C. Circuit breakers are used in place of contactors for motor starters when the fault KVA of the power system is greater than the rating of the contactor type starters being considered. 250 MVA at 5000 volts is the top rating of contactor type starters when using current limiting fuses. However, starters with fault limiting reactors may be used on systems with unlimited fault capacity. The only limitation is that of horsepower size. HI's Valimitor starter is the only device marketed with current limiting reactors included as an integral part of the starter and designed specifically for motor starting applications. Separate reactors can be purchased from other manufacturers, but special design and installation considerations are necessary for motor applications.

D. Contactors can be used in place of circuit breakers when a simple magnetic disconnect is desired. This can be practical and economical if applicable on systems having the current, voltage, and available faults within the contactor rating. Fuses or air core reactors may be used with the contactors to increase the fault rating. Transformer primary disconnects are sometimes built this way. The limitations of contactors for such applications, as discussed below, must be fully realized first.

E. Quite often an installation will consist of a large number of feeder and transformer disconnects with only a few motor starters. It may be practical to use circuit breakers instead of contactors for the motor starters. Conversely, an installation may consist of a large number of motor starters with only a few feeder or transformer disconnects. It may be practical to use contactors instead of circuit breakers for the feeder or transformer disconnects. In both cases the substitutions are made in order to have a uniform installation with all the units having similar parts. The limitations of both devices for the specific application should be considered thoroughly before any substitutions are made.

In general, the cross application of circuit breakers and contactors is not good practice. Some of the important characteristics and design features of both high voltage devices are outlined below. The numbers indicate paragraphs below giving more details.

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Tabulation of Comparisons - Cont'd.			
Circuit Breakers		Contactors	
	5. Designed for Infrequent Operations	6. Designed for Frequent Operations	
8. Higher Contact Pressures			9. Lower Contact Pressures
	10. Does Not Fail Safe	11. Fails Safe	
12. No Blowout Coil Power Loss			12. Blowout Coil Power Loss
	14. Usually Slower Operating	14. Faster Operating	
16. Replaceable Unit With Power Stubs			16. Most Designs Are Not Replaceable Units with Power Stubs
	16. Maintenance Difficult With Replaceable Units Not Always Practical	16. Maintenance Usually Easier	

1. A circuit breaker is usually a magnetically closed and mechanically latched device. Designs other than direct magnetic slowing may be encountered such as spring or air operation. The mechanically latched design can allow power to be maintained on momentary or extended low voltages. The circuit breaker is not necessarily disconnected on power outages. This can be the intended purpose on incoming line units, feeder and transformer disconnects. In this case, resetting of the breakers is not required.

2. On motor starter applications, the mechanically latched feature of circuit breakers is not recommended. Ordinarily motors should not be energized on low voltages, even though the overload relays would eventually protect them. On return of power after an outage, motors will start up automatically if the starting device is latched in. This is

not always a desirable condition. An additional feature can be added to circuit breakers to provide undervoltage protection and have the breaker trip open. This is added mechanical or electrical equipment and cannot compare with the simplicity of a contactor.

3. A contactor is normally a magnetically closed and magnetically held device. Power will be interrupted on momentary or sustained low voltages below the minimum holding voltage of the operating coil. This is the intended purpose for motor starters, to provide simple and positive low voltage protection.

4. When a contactor is used as an incoming line circuit breaker, feeder, or transformer disconnect, a momentary or sustained low voltage could de-energize the contactor and interrupt power completely to the system. Low voltage might be preferred on a system for a while instead of a complete outage. It is possible to modify the contactor type starter electrically and provide a circuit which will keep the contactor energized to approximately 25 or 30% of normal voltage. HI's exclusive capacitive undervoltage protective circuit accomplishes this. In special cases, this feature might permit a contactor to be used as a simple magnetic disconnect in place of a more expensive circuit breaker. All the details of such an application should be analyzed to insure satisfactory performance with this substitution.

5. An air break circuit breaker is designed primarily for infrequent circuit interruptions. It is opened and closed electrically, initiated by master switches or protective devices. The spring loaded opening design insures operation after long periods of being closed. Generally speaking, circuit breakers can be operated trouble-free for 2000 to 15,000 times without the necessity of rebuilding, depending on the size, design, and application. This usually satisfies the needs of feeder or transformer disconnects for many years without repairs.

6. A contactor is designed primarily for a large number of operations, in the order of a million or more without major repairs. HI's mill type (clapper) contactors have been operated over 2-million times without failing. The vertical lift high voltage contactors do not appear to be able to take as much abuse without failing. Many repeated operations at normal current are common for contactors without inspection or repairs. This is a necessity for motor starting or controlling applications where operations are frequent and continuity of service is important.

7. Without the spring loaded opening design of a circuit breaker, the same positive operation might not be assured when contactors are applied on feeder or transformer disconnects that are closed for

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long periods of time. Contactors cannot readily be designed with high contact pressures equivalent to circuit breakers. Also, the current carrying ability of a contactor can be reduced when continually energized for many weeks unless special provisions are included. Copper to copper contacts will gradually heat and form an oxide causing further heating which becomes progressively worse when continually energized. This can destroy the contactor eventually. Alloy contact tips suitable for repeated operations or continuous duty can greatly improve this undesirable feature.

8. The mechanically latched-in design of circuit breakers permits high contact pressures. Equivalent pressures with magnetic holding coils of contactors would not be practical. With this mechanically latched-in feature and spring loaded opening feature of circuit breakers, welding closed due to low contact pressure or high currents on closing is greatly reduced. The emergency opening of a branch circuit is generally assured.

9. Contactors being a magnetically held device are susceptible to welding more than circuit breakers. A low voltage condition can result in low contact pressure, and when large currents are flowing during the closing or the opening of a contactor, welding of the tips can occur with the contactor in the kiss position. Very high currents for short durations are common on feeder or transformer installations. The use of copper alloy or silver alloy tips as compared to plain copper or silver faced tips will reduce welding of the tips considerably. Also, by incorporating a circuit modification, the same that enables a contactor to remain energized with approximately 25 or 30% rated voltage, the operation of the contactor when opening on low voltage can be made positive instead of hesitant at the kiss position and virtually eliminate welding.

10. Because of its mechanically latched-in feature, a circuit breaker requires energizing of its trip coil to de-energize the power circuit. In the terms of motor control design, this is not a fail safe scheme. Should the trip coil fail, the circuit breaker could not be de-energized normally. This feature in circiut breaker applications is justified because fail safe requirements are not considered in the same respect as they are with motor control. Also, the tripping coil would not be subjected to as much abuse as it would on a repeatedly operated application. For feeder and transformer disconnects, the circuit breaker as applied is more effective with the latched-in design rather than having a magnetically held fail safe design.

11. Because of its magnetically held feature, a contactor can be used as a fail safe device. Failure of the holding coil will automatically de-energize the circuit. In motor control design, fail safe is fundamental.

12. In many designs, the blowout coils on contactors are in the circuit all the time. This is not so with circiut breakers. For a continually energized application and with large amounts of current flowing, the power losses attributed to the blowout coils may be high enough to be objectionable.

13. The inverse time characteristics of circuit breaker overload components are designed to match those of branch circuit feeders and transformers as closely as possible. The overload relays are usually the induction disc operated type. Their settings are flexible with time controlled tripping. Thermal characteristics of motors differ appreciably from those of open or enclosed cables. Overload protection of motors requires relays with thermal characteristics similar to those of motors. Thermal overload relays used with contactor type motor starters are purposely designed to meet this requirement and may not give the desired protection for cables or transformers. It is possible to substitute the induction disc relay type overloads with their many variables in contactor type starters and obtain acceptable tripping characteristics for cables or transformers. Likewise, circuit breaker starters can have thermal overload relays included for motor protection.

14. Most older circuit breaker designs have longer operating times than contactors. Generally, these circuit breakers operate in the order of 6 to 8 cycles. Some newer circuit breaker designs have faster operating times and can compare with contactors. Contactors can operate in the order of 2 to 3 cycles. This includes overload operation and arc extinction time. For motor starter applications, the fast operating time of a contactor during severe faults limits the equipment to less thermal and mechanical strain. Also, the use of current limiting fuses, quite often applied with contactor type starters and not ordinarily applied with circuit breaker type motor starters, can appreciably limit the fault current to the motor. When the fuse clears a fault in 1/2 cycle or less, it limits the peak fault current and gives additional protection to the equipment against mechanical or electrical stresses. This is not obtained with circuit breaker starters.

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15. Since contactors can operate in 2 to 3 cycles, they may be required to interrupt a substantial portion of the decaying dc component during a fault. Circuit breakers, when operated at 6 to 8 cycles, are not required to interrupt as much of the dc component because it will have decayed practically to zero. Fast operating breakers will be required to interrupt some of the dc component. Contactors are rated in symmetrical KVA, and this rating includes any dc component that may be present. The application of circuit breakers for interrupting ability is more complicated. The operating times and published interrupting ratings should be analyzed carefully to determine whether or not any dc component will be included.

16. Due to the importance of continued electric service and coupled with the duty limitation and complexity of circuit breaker maintenance, most feeder and transformer disconnects are designed with the circuit breaker mechanism as a draw-out replaceable unit. Very little time or effort is required to make the change and this is desirable for feeder installations. Contactor type equipment is not usually designed with replaceable units since it is normally more sound mechanically and able to take more abuse without maintenance. Maintenance of contactors can be considerably easier than circuit breakers, and normally short down times for maintenance can be scheduled and tolerated with motor installations. Some contactor type starters do have roll-out and replaceable unit designs for maintenance of the contactor. This can be practical or impractical for motor installations, depending on the specific application and starter design. HI's contactor is designed specifically for easy maintenance without removing from the enclosure. This is not always the case with competitive starters.

In summing up, each device should be used as it was originally intended, circuit breakers with branch circuit feeders and transformers, contactors with motors. There are exceptions to this and after careful consideration of all conditions by the user and manufacturer, it may be advantageous to substitute one for the other's normal application.

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