

DHP-VR *SURE CLOSE* Mechanism: Kinetic System Solution For MV Circuit Breaker MOC Auxiliaries Operation

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Abstract

The interface of a medium voltage metalclad breaker with the auxiliary switches in the switchgear cell is addressed. This interface has been a cause of concern in the industry, especially when applying vacuum breakers in cells originally designed for magnetic air breakers. Special attention has been included in IEEE C37.59-2007 due to MOC failures and breakers stalling during close and latch operations.

The technical aspects of the interface are discussed, and the root cause for interface performance problems is identified to be the increased speed of operation of the vacuum replacement breaker.

The DHP-VR *SURE CLOSE* mechanism is discussed, along with the application and methodology employed. The *SURE CLOSE* mechanism is effective in slowing down the interface speed to acceptable velocities as well as assuring proper breaker operation irrespective of the loading by the cell auxiliaries.

Eaton's Power Breaker Center is believed to be the first in the industry with a kinematic system solution for older switchgear auxiliary switch interfaces and studies and tests have confirmed the problem exists industry wide.

Introduction

When designing replacement circuit breakers utilizing modern interruption technology, it was well known that the speeds, force, and travel were different from the older circuit breakers being replaced. Such changes in parameters can be the "Achilles Heel" of a new technology. This did not seem to be an issue with the Eaton VR-Series of DHP-VR replacement breaker (manufactured by Eaton's Power Breaker Center), since successful design tests had been conducted with DHP-VR breakers in Westinghouse DHP switchgear cells.

What we have learned is that equipment that has been in service 20-40 years is definitely not in the same condition as new, and several auxiliary MOC switch problems came to light when applying the DHP-VR replacement breaker in older DHP switchgear cells containing MOC operators.

This paper specifically addresses the DHP switchgear and circuit breakers, but the issues and solutions apply to all air-magnetic to vacuum conversions. Eaton's Power Breaker Center undertook a design program, originally initiated by Eaton's Technology Center, to solve the fundamental problems encountered with most all ANSI manufacturers air-magnetic to vacuum conversions. The same laws of physics apply, regardless of manufacturer. This article covers the background, issues and solution that was developed.

Background

What is a MOC? A MOC is a mechanism operated cell switch that is located in the switchgear cell, but operated by the circuit breaker mechanism. It is used to provide extra or redundant contacts for breaker status indication and other control functions. **Figure 1** shows the elements of a MOC system in a DHP Switchgear Cell. The MOC operator on the circuit breaker engages the MOC pantograph assembly in the cell. (The pantograph assembly permits the MOC's to operate when the circuit breaker is in the connected and / or test positions.) The pantograph assembly is connected to the MOC switches in the cell by the MOC drive rod. As the circuit breaker closes, the MOC operator travels downward, forcing the pantograph assembly down, which pulls on the drive rod, which causes the MOC switches to rotate.

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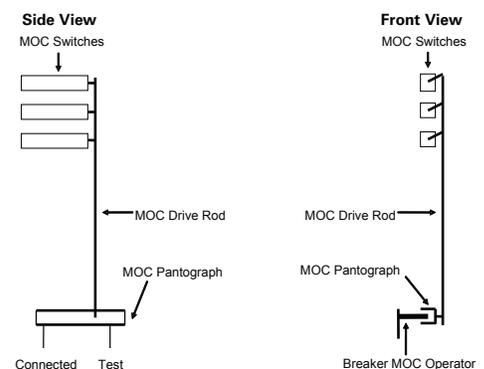


Figure 1. DHP MOC System

Older switchgear MOC designs were designed for the circuit breaker technology of the time. Older technology breakers had massive mechanisms, with high forces and inertias. The resultant travel times and velocities were fairly slow. **Figure 2** shows the closing curve of the DHP MOC operator. Notice that the breaker closes in approximately 100 msec (a tenth of a second), measured from the time the breaker begins to close.

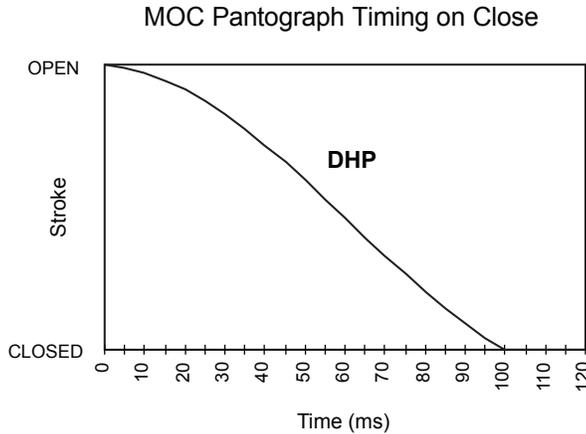


Figure 2.

The MOC assembly in the switchgear cell is the only item outside the circuit breaker that affects the dynamics of the circuit breaker. The MOC's loading and dynamic characteristics also change with time as it experiences mechanical wear and degradation.

A modern technology vacuum replacement breaker, such as the Cutler-Hammer DHP-VR, is much smaller and lighter than the magnetic air Westinghouse DHP breaker. The vacuum contacts in the breaker move a much smaller distance than the magnetic air breaker contacts, and it operates much faster. When the DHP-VR breaker is applied to a DHP cell, the resultant speed of operation of the MOC becomes much faster than with a DHP breaker. The result is higher impact loads and mismatched inertias with the existing switchgear MOC.

This breaker / MOC mismatch has been an unresolved issue for all vacuum replacement circuit breakers, not just the DHP-VR.

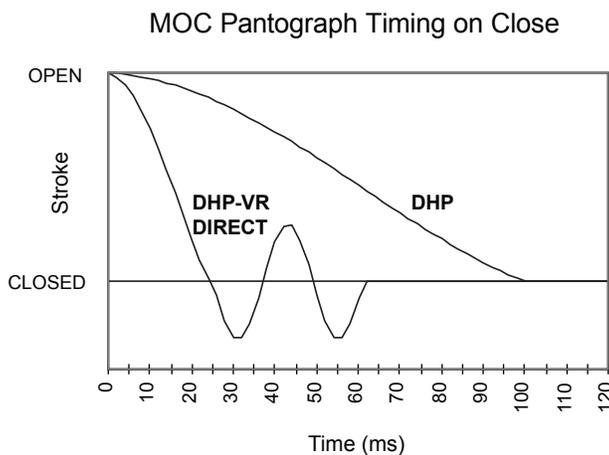


Figure 3.

With the DHP-VR breaker directly driving the MOC, the breaker and the MOC pantograph complete the closing stroke in 25 msec. (one fortieth of a second), versus the 100 msec. for the DHP breaker. The velocity of the MOC system is essentially 4 times what it was with the DHP breaker. Since kinetic energy is proportional to velocity squared, the kinetic energy of the MOC has increased to 16 times that of the original design. (During an opening stroke, the velocity multiplication occurs as well.)

This dramatic increase in kinetic energy creates the following results:

- Significant MOC pantograph over-travel and bounce (for up to 35 msec after the breaker closes)
- MOC switch "contact bounce" during pantograph over-travel and bounce
- Increased MOC component wear
- Increased MOC component breakage

In simple terms, the DHP-VR breaker operates too fast for the DHP MOC mechanism.

In addition, there is another aspect of this situation that is potentially much more serious.

In the worst case, a badly worn or broken MOC in the cell could stall the breaker.

The **SURE CLOSE** Solution - A Technical Discussion

The DHP-VR vacuum breaker had enough energy to drive the original DHP MOC system in the switchgear, but as a direct drive MOC operator, it had two inherent problems:

- It operated too fast
- The breaker could be stalled by a worn or damaged MOC system.

The design goal was therefore to develop a simple DHP-VR breaker MOC drive system that would slow down the MOC operation to acceptable levels and also eliminate the possibility of the MOC stalling the breaker.

This was done by installing a spring in the circuit breaker MOC operator to drive the existing DHP MOC pantograph assembly in the switchgear. However, the amount of force required to operate the MOC changes with the number of MOC switches in the switchgear, as shown in **Figure 4**.

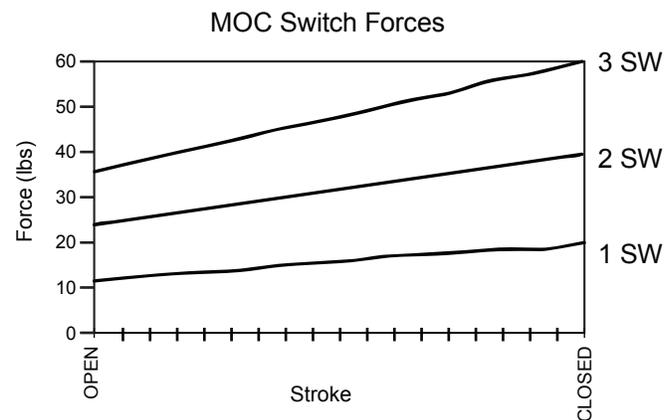


Figure 4.

The MOC drive spring force can be adjusted to match the MOC switch conditions, as shown in **Figure 5, 6, & 7**. The goal is to provide enough closing energy to reliably close the MOC pantograph assembly and also to limit the closing velocity of the MOC pantograph assembly. Note that the closing energy is the area of the graph between the Drive force curve and the MOC switch force curve.

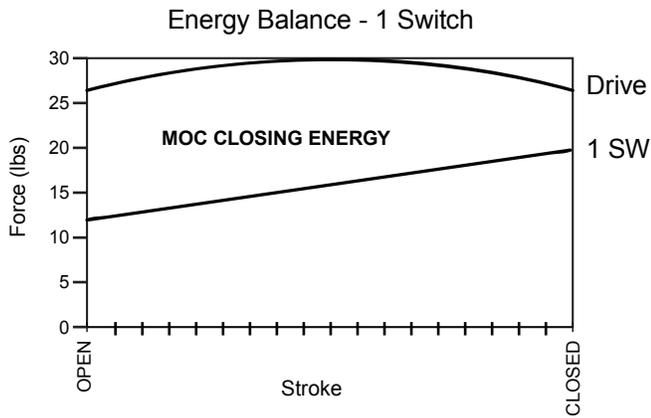


Figure 5.

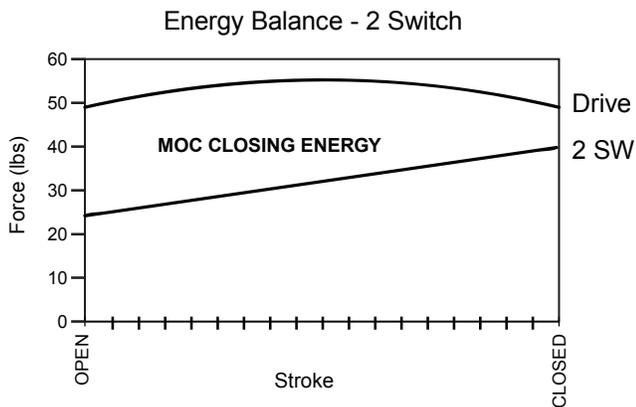


Figure 6.

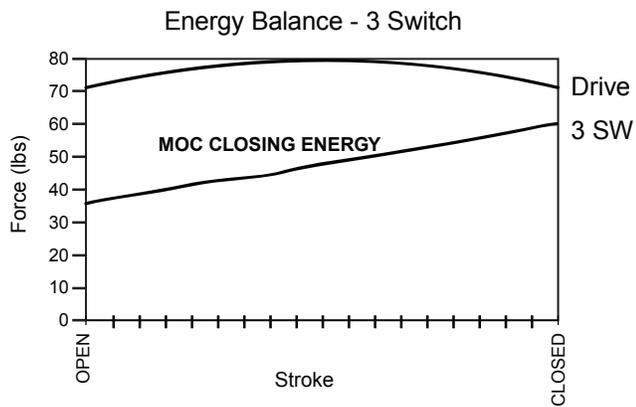


Figure 7.

The MOC drive spring in the breaker is compressed when the breaker is opened, and is connected to the circuit breaker MOC operator. When the breaker closes, the MOC drive spring is released, providing the energy to the circuit breaker MOC operator to drive the MOC pantograph assembly to the closed position. By controlling the closing energy of the MOC system, the velocity during closing is also slowed down to an acceptable level, as shown in Figure 8.

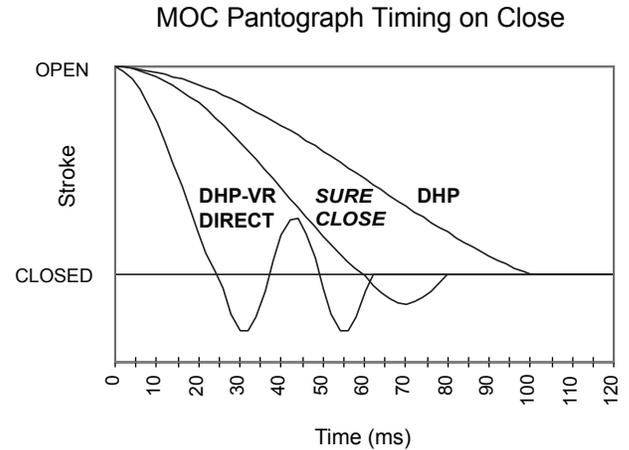


Figure 8.

The *SURE CLOSE* MOC drive approximates the original DHP MOC response much better than the DHP-VR direct drive. The single, smaller MOC pantograph over-travel with the *SURE CLOSE* drive does not cause MOC switch contact bounce or abnormal wear.

This method of adjusting the spring to the number of MOC switches effectively controls the response of the system. More importantly, it isolates the moving mass of the MOC pantograph system in the cell from the dynamic behavior of the circuit breaker.

This is why the drive mechanism is called *SURE CLOSE*. Nothing in the MOC system in the cell can affect the reliable closing or opening of the circuit breaker mechanism.

Field Applications

The DHP-VR *SURE CLOSE* mechanism achieves the goal of controlling the MOC velocity by balancing the available closing energy with the MOC mass and return springs. As a result, a field adjustment may have to be made to the *SURE CLOSE* mechanism on the breaker. This adjustment is very simple and should be done during commissioning of the circuit breaker in the cell.

The adjustment is made by setting the compression of the MOC drive spring on the breaker. There is a nut and a jam nut on the threaded rod to make the adjustment easy to do. A gauge is provided next to the drive spring to further simplify the task, as shown in Figures 9, 10 and 11:

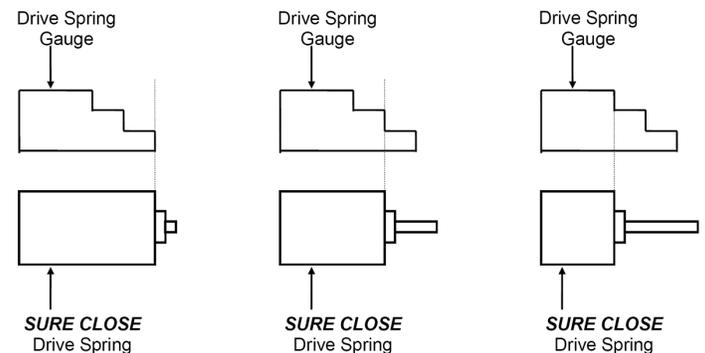


Figure 9.

Figure 10.

Figure 11.

The breaker is set at the factory for an application of one MOC switch. This means that for cell applications with either no MOC switches or one MOC switch, no field adjustments to the *SURE CLOSE* mechanism have to be made. From our records, this about 90% of the applications, as shown in Table 1.

Table 1. DHP-VR MOC Applications in DHP Cells

Percent	Number of MOC Cell Switches				<i>SURE CLOSE</i> Adjustment
	0	1	2	3	
50%	X				Not Required
40%		X			Figure 9
<10%			X		Figure 10
<10%				X	Figure 11

It is only for the cases of 2 or 3 MOC switches that the drive spring adjustment is required on the circuit breaker. The adjustment is done with the breaker out of the cell, with the breaker open, and all breaker mechanism springs discharged.

It is important to note that a DHP-VR breaker with the *SURE CLOSE* mechanism adjusted to any MOC condition (one, two or three MOC switches) will work properly in a cell without MOC's.

There are some field cases where a given breaker could be installed in a number of cell locations and the number of MOC switches varies over those cell locations. In these cases, where breaker interchangeability is required, you have two options:

- Adjust the breaker to the individual cell MOC condition per Table 1. If you move the breaker to a cell with a different MOC condition, the breaker must be re-adjusted. This is just a 5 minute operation.
- Adjust the breaker for the maximum MOC condition for all the cell locations, and add an available compensation spring kit in the cells with fewer than the maximum. The compensation spring kit is designed to maintain the energy balance required in the system.

This begs the question of what happens if the *SURE CLOSE* mechanism is not adjusted properly for the MOC condition?

There are two potential results:

1. If the breaker *SURE CLOSE* mechanism is adjusted for more switches than the actual MOC condition, the system will operate but increases in MOC mechanical wear, switch contact bounce, and over-travel will occur.
2. If the breaker *SURE CLOSE* mechanism is adjusted for fewer switches than the actual MOC condition, the MOC assembly in the cell will not fully close, and the MOC switches may not properly indicate the true breaker status.

In either of these cases of mis-adjustment, the *SURE CLOSE* mechanism assures that the breaker operation is unaffected.

The *SURE CLOSE* mechanism also allows an effective way to evaluate the condition of the MOC in the cell. If the breaker *SURE CLOSE* drive spring is properly adjusted for the number of MOC switches in the cell, but the MOC doesn't fully open or close, you know that it is time to maintain the MOC in the cell. Usually that would just mean cleaning and lubrication of the MOC mechanism, but if the MOC has seen a lot of cycles, it may be time to replace the worn MOC components.

Conclusions

The new patented DHP-VR *SURE CLOSE* mechanism has the following features:

- The MOC cannot stall the breaker
- MOC Switch mis-operation (contact bounce) is eliminated
- Energy balance reduces impact loads, increases MOC component life, and increases circuit breaker and MOC system reliability
- The user can easily evaluate the condition of the MOC system
- It is a tested cell interface system solution, incorporating both the circuit breaker and cell auxiliary switch mechanisms, tested to greater than 10,000 operations

The new DHP-VR *SURE CLOSE* mechanism provides the first energy balanced MOC system design, specifically designed for the installed base of DHP MOC cell systems.

Breaker operation is now separated from MOC varying loads and dynamics, assuring that a failure of a MOC operator in a cell cannot stall or affect the operation of the circuit breaker in any way.

The drive system mimics the old breaker dynamics and velocities, which prevents MOC switch contact bounce and minimizes impact loads, mechanical wear and parts breakage. Mechanical reliability for both the circuit breaker and the MOC assembly is increased.

Authors

Ron Vaill is a consultant to the electric power industry. He served numerous years with Westinghouse Electric Corporation Research and Development and later as Eaton's Aftermarket Product Manager. Ron has nine approved patents and was the original author of the Sure Close document.

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