DATA CENTER – UNIQUE CHARACTERISTICS AND THE ROLE OF MEDIUM VOLTAGE VACUUM CIRCUIT BREAKERS

ABSTRACT

Data Centers are a critical part of the world economic systems. Billions of electronic transactions happen via data centers per year. These transactions can contain financial transactions that are critical to the parent company. Large credit card companies never want their system to be down even for a second and or a micro-second. Therefore, reliability is a major important factor to the customers. In addition, the customers are focused on their energy spend (efficiency) via the data center. They would like to make the plant operate with the lowest possible energy consumption. Medium Voltage Vacuum Circuit Breakers have a major role in Data Centers.

Data Centers have a number of unique characteristics and or needs. Some of the characteristics are unique to this market segment.

Data Centers are a fast growing sector of the Medium Voltage Breaker market.

Medium voltage circuit breakers with enhanced capabilities in concert with state-of-the-art protective/monitoring devices, for example, can help to simplify the task of providing power to the data centers and increase the value to the end customer.

INTRODUCTION

This paper will discuss to a limited degree how data centers work, how electricity is utilized, system equipment challenges, and the role of medium voltage circuit breakers in the overall scheme. The focus will be on medium voltage vacuum circuit breakers with special capabilities and characteristics that address some of the unique challenges experienced in data centers.

TREND TO MOVE FROM LOW VOLTAGE TO MEDIUM VOLTAGE BREAKERS

In the past data centers would use only a few Medium Voltage breakers for a whole system. The power would be brought into the site via Medium Voltage and then quickly transformed to Low Voltage. This means a large amount of the breakers protecting the system would be Low Voltage Power Breakers. A growing trend in the industry is to bump up from Low Voltage to Medium Voltage. This is a change to increase the efficiency of the system.

ELECTRICAL SYSTEMS

Typical electrical systems have one power source for the whole building. If the power is lost at the utility source then the power is shut off to the building. One level higher of power protection is to put a backup generator in the system as a backup. Typically these systems can be switched on if the power is lost. This transition can normally take seconds and or minutes to complete.

Data centers have moved towards a special class of electrical systems that basically have two complete power systems that are interlaced with special UPS systems that allow for seamless transition of power from one source to another without dropping power. These systems in general normally take up twice the space and have twice the amount of protection products in the system. These systems are setup to avoid the system being down for any amount of time.

Eaton® has Medium Voltage Breakers (VCP-T and VCP-TL) that greatly reduce the footprint required for the total gear. In addition, the Eaton MEF front access gear allows for the gear to be placed up against a wall without a walkway to reduce the gear size. For the Data Center market this allows the consultant and or building manager to be able to fit more products in a smaller location.
CATAGORIES OF FACILITIES

Three general facility size categories of data centers are:

- Large – 250,000 Square feet or larger
- Medium – 20,000 to 249,000 Square feet or larger
- Small – Less than 19,000 Square feet. This category also covers remote locations and hubs.

Four tiers of protection for data centers:

- Tier IV – Highest degree of redundancy and or protection
- Tier III
- Tier II
- Tier I

ELECTRICAL EQUIPMENT SUPPORT

Data centers are typical used for financial (Bank) transactions. Secondary usages are for web related activates (IT). The third category of usage is for telecommunications (telephone and cable).

Data centers normally have about 23% - 54% of their energy usage associated with cooling of the equipment / facility. In addition, 38% - 63% is normally going to the IT loads at the facility. The high performance servers in the facility cause a large degree of heat which needs to be cooled down to avoid server problems. Each year higher capability servers are released that release more heat. Therefore, more heat needs to be pulled out of future installations. In addition, the virtualization and consolidation of servers to blade servers is driving higher power densities in data centers. Moving toward Medium Voltage breakers allows for consultants to grow / expand the capabilities in the same size footprint.

MEDIUM VOLTAGE VACUUM CIRCUIT BREAKER FOR DATA CENTER APPLICATIONS

This discussion will concentrate on:

- Primary voltages from 5 to 15 kV
- Reliability
- Operating cost efficiency
- Effective use of capital
- Safety
- Uptime
- Risk management
- Switching capabilities
- Extra capability requirements
- Long life and minimal maintenance
- Limited space installations
- Monitoring needs

Eaton offers a technologically advanced family of medium voltage vacuum circuit breakers from 5 through 38 kV designed to address many of the stringent requirements of the data center market. In addition, Eaton circuit breakers are well accepted by utilities around the country and have already been applied in almost all applications. Data centers normally have Medium Voltage breakers in the 5-15 kV categories.
Reliability is very important for data centers. The Medium Voltage breakers within these systems must have a high degree or reliability. Eaton has worked diligently to reduce the mechanical and or electrical issues associated with our products to increase the reliability. In addition, Eaton has focused on using Six Sigma tools to increase the reliability and endurance of the product to the high levels expected by data center customers. Some useful tools used were Wiebul Analysis, Design of Experiments (DOE), and Design for Manufacturing (DFM) / Assembly (DFA).

Operating cost efficiency is an important factor that consultants use when they specify a data center. The change to Medium Voltage allows for a significant increase in efficiency of the building versus systems that use Low Voltage breakers.

Data Center consultants also specify the systems so that they can make a more effective use of capital. The equipment needs to be lower cost, smaller size, with extended life cycles, and higher service protection. Eaton has offerings that allow the customer to have lower up front and long term costs. As an example the MEF MV gear is smaller than traditional gear via using the VCP-T or VCP-TL Medium Voltage breakers. The VCP-TL Linear actuator breaker has at least a 3X mechanical life. This allows the product to be used more frequently without reducing the total life cycle.

Safety to users and or workforce at the facilities is a growing need at the facilities. Some sights take extra measures in terms of safety to try to reduce the insurance costs. Eaton has responded by coming out with the new 520MCV with ARM’s and 1150V Integral Protective Relay. These relays have a safety related setting that reduces the available arc energy when selected by the maintenance personnel when they are working on a machine. Eaton also has Partial Discharge measuring system that detects partial discharge issues prior to having an arc event. This helps avoid arc fault issues.

In order to maximize uptime the data centers use redundancy systems. The Medium Voltage breakers in these systems are increasing the reliability to keep the systems working efficiently.

Data centers are often performing risk management analysis’s to verify the risk inherent in their systems. The enhancements to Eaton Medium Voltage breakers mechanical and electrical capabilities allows for a lower risk solution. As an example the VCP-TL linear actuator breaker has a longer life which reduces the chances of end of life failures. Another example is that the 520MCV with ARM’s reduces the available arc energy to reduce the risk of major burns to the maintenance workers.

**CIRCUIT BREAKER VOLTAGES**

The Eaton VCP family of vacuum circuit breakers covers 5, 15 and 38 kV applications. The specific application will normally determine the circuit breaker type most suitable. There are three major customer choices best suited for data center needs:

- VCP-WC Extra Capability Circuit Breaker (5-38 kV frame sizes) (Figure 1)
- VCP-T Space Saving Circuit Breaker (5-15 kV frame sizes, via a conventional spring stored energy mechanism) (Figure 2)
- VCP-TL Space Saving Linear Actuator Breaker (5-15 kV frame sizes) (Figure 3)

Each specific circuit breaker will be discussed in more detail later in this paper.
Figure 1 – Typical 5 and 15 kV VCP-WC Extra Capability Vacuum Circuit Breaker

Figure 2 – Typical 5 and 15 kV VCP-T Space Saving Vacuum Circuit Breaker (conventional spring stored energy mechanism)
CIRCUIT BREAKER TYPES

The requirements for data center applications are not only somewhat unique, but varying as technological advances are made in the industry. Now circuit breaker manufacturers must go beyond considering just the pure electrical needs. This fact makes it difficult for one-size fits all approach to meeting the industry’s electrical requirements. A variety of considerations are necessary:

- Generator needs
- Distribution needs
- Physical size
- Operational and maintenance longevity
- Condition monitoring and communications

VCP-TL LINEAR ACTUATOR CIRCUIT BREAKER

Data center circuits have unique characteristics that require specially designed and tested circuit breakers. The Eaton VCP-TL (Figure 3) breaker is an excellent choice for data centers.

The Eaton linear (magnetic) actuated circuit breaker has taken a huge step in the direction of a medium voltage circuit breaker for use in distribution systems and or data centers with significantly reduced maintenance, greatly increased operational ratings, and reduced life cycle costs. In addition, it is noticeably smaller and lighter than comparable breakers because of smaller internal components. The result is a highly reliable circuit breaker with mechanism capable of 100,000 operations due to its small number of moving parts. The mechanism has fewer moving parts and therefore fewer chances for process related problems.
The linear (magnetic) actuator mechanism is relatively maintenance free over its lifetime. Two control voltages are available. A low control voltage range of 36-60 Vac and 36-72 Vdc and a high control voltage range of 100-240 Vac and 100-353 Vdc. The electronic controller was tested for operational integrity for the extended life of the circuit breaker. All normally expected and required safety features previously associated with spring stored energy circuit breakers, such as trip free operation, an anti-pump feature and other safety interlocks are provided.

The loss of control power is of no concern since the circuit breaker can have an OPEN operation performed up to 48 hours after the loss of control power. In addition, the circuit breaker can be opened using its integral front mounted emergency open handle at any time.

The linear actuated medium voltage circuit breakers and the extra capacity versions are tested to ANSI Standards. The draw-out configuration is a three-position draw out (Disconnect, Test, Connect) device used in conjunction with a fixed draw out cassette. Fixed configuration devices utilize bolted bus or cable connections.

An integrally mounted microprocessor-based Digitrip trip unit (protective relay) can be used to add a large number of sophisticated features to the circuit breaker. These features range from protective features to displays to monitoring and communications. Having the relay integral to the breaker allows for the breaker and relay to be certified from the production plant as complete systems instead of as two components. This increases the reliability and avoids external wiring breaks.

Finally, the circuit breakers use highly reliable Eaton vacuum interrupters for circuit interruption, certainly the preferred interruption method used today worldwide.

**EXTRA CAPABILITY CIRCUIT BREAKER**

Eaton VCP-WC extra capability vacuum circuit breakers were designed to provide extra capabilities for those application requirements that go beyond what is normally experienced (Figure 1). The performance enhancement features make it an ideal choice for:

- Capacitor switching duty
- High altitude applications
- Transformer secondary fault protection
- Locations with concentrations of rotary machinery
- High operating endurance requirements

VCP-WC extra capability vacuum circuit breakers are available in drawout (VCP-WC) or fixed (VCP-WRC) configurations from 5 to 15 kV at 25 to 63 kA (K=1), 27 kV at 16 to 40 kA (K=1), and 38 kV at 16 to 40 kA (K=1). Continuous current ratings are up to 3000A with natural air convection cooling. Forced air-cooled and/or paralleled VCP-WC circuit breakers can also be considered to meet higher continuous current requirements.

In addition, VCP-WC extra capability vacuum circuit breakers offer:

- Tested ratings for definite purpose capacitor switching
- Higher mechanical endurance ratings
- Higher close and latch capabilities
- Faster transient recovery voltage
SPACE SAVINGS CIRCUIT BREAKER

The data center industry is often confronted with challenges that might not normally be faced by other end users. The Eaton VCP-T and VCP-TL family of medium voltage vacuum circuit breakers was designed for use where space is at a premium (Figure 2). The VCP-T circuit breaker is 60% smaller and 50% lighter than comparable breakers. It is a design that performs without compromise in spite of its size. Since the circuit breaker is significantly smaller, it is contained in a smaller less noticeable enclosure assembly. All of these considerations are a significant part of the somewhat unique characteristics of the data center customers.

In addition to the significant savings associated with smaller size, VCP-T and or VCP-TL also features:

- Capacitor switching capabilities
- Integral Digitrip protective relay
- Higher mechanical endurance
- Reduced/simplified maintenance
- Common family of accessories

This family of circuit breakers is ideal for applications such as restricted access locations, low profile areas, and remote installation locations. VCP-T type space saving vacuum circuit breakers are available in drawout (VCP-T) or fixed (VCP-TR) configurations from 5 to 15 kV with short circuit breaking current up to 40 kA, and continuous current ratings up to 2000A.

VCP-TL and VCP-TRL circuit breakers are also available featuring a linear actuator mechanism for an even higher degree of reliability with less maintenance up to 25 kA 1200A (Figure 3).

The entire VCP-T family of circuit breakers has a mechanical endurance rating of 10,000 operations. VCP-TL and VCP-TRL circuit breakers have a mechanism mechanical endurance rating of 100,000 operations (parts replacements required at 30,000 operations).

PROTECTIVE RELAYS

Microprocessor-based protective relays (trip units) offer distinct and measurable advantages over their electromechanical counterparts:

- Operational
- Flexibility
- Initial cost
- Installation cost
- Maintenance cost
- Feature capabilities

The data center industry of today needs and expects more in the way of greater performance, improved reliability, wider application ranges, lower maintenance, operational simplification, and more sophistication. The Eaton Digitrip family of protective relays takes a significant step in that direction (Figure 4). The entire family of VCP-T and or VCP-TL circuit breakers is available with Digitrip integrally mounted, and fully integrated in the circuit breaker itself.

The optional Digitrip protective relay offers:

- RMS sensing
- Microprocessor-based
- Self powered
• Local testing
• Model 520V for basic LSIG protection
• Model 1150V for advanced LSIG protection, metering and communications
• ARM’s arc flash reduction mode

The Digitrip protective relay is the most advanced means for providing the intelligence required, no matter how sophisticated the requirements. This is especially valuable for remote locations where rapid responses are required and frequent changes expected.

Figure 4 – Typical 1150V Digitrip Protective Relay (Trip Unit)

The Model 1150V is not only programmable locally via a keypad, it can be programmed remotely over a communication system (Figure 5). Information about critical parameters, such as power factor, voltage, current, harmonic distortion values, and waveform capture, are monitored and can be displayed with a three line LED window on the face of the protective relay or communicated to a remote location.
Figure 5 – Typical Integrally Mounted 1150V Digitrip Protective Relay Being Locally Programmed

Figure 6 – Graphical representation of a typical Data Center.
CONCLUSIONS

Electrical equipment support will remain a critical factor when it comes to the degree of success achieved by the data center industry. Equipment must be increasingly sophisticated and operationally superior. Manufacturers must focus on how to provide equipment with advanced capabilities requiring less frequent attention and longer life. This is quite a challenge and overall applicable, regardless of the type of electrical equipment being considered. Eaton Medium Voltage Vacuum Circuit Breakers are capable of handling the unique needs of the data center market.

REFERENCE

1. http://www.eaton.com

About Eaton

Eaton Corporation is a diversified power management company with 2007 sales of $13 billion. Eaton is a global technology leader in electrical systems for power quality, distribution and control; hydraulics components, systems and services for industrial and mobile equipment; aerospace fuel, hydraulics and pneumatic systems for commercial and military use; and truck and automotive drivetrain and powertrain systems for performance, fuel economy and safety. Eaton has 82,000 employees and sells products to customers in more than 150 countries. For more information, visit www.eaton.com.

About The Author

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