IMPROVE ELECTRICAL SYSTEM RELIABILITY WITH MAGNETIC CIRCUIT BREAKER SWITCH PANELS

Stuart A. Owades
Wired Rite Systems, Inc.

ABSTRACT

Electrical failures in vehicles are commonplace and are a source of serious concern for vehicle operators, maintenance personnel and fleet managers. Traditional switch panel designs utilizing switches designed for household appliances are often the source of electrical failures. Switch panels designed with magnetic circuit breakers as the circuit switching mechanisms provide a more reliable and safer method of controlling electrical apparatus. In conjunction with magnetic circuit breaker switches, solid state back lighting of switch functions provide a higher degree of reliability and performance.

This paper explores electrical problems experienced by operators and maintenance personnel in the state fleet and public works sectors. Solutions to common problems are discussed. Emphasis on magnetic circuit breaker protection and solid state back lighting as a reliable means of controlling and identifying switching circuits are discussed in detail.

INTRODUCTION

With respect to vehicle breakdowns, electrical problems rank high on the list of common occurrences. Electrical failures are typically traced to faulty apparatus, wiring harnesses, switching systems or a combination of all. Manufacturers of quality electrical apparatus used in public works vehicles generally have an excellent reliability record and provide a product that often outlasts the life of the vehicle. Wiring harnesses, if designed and constructed properly should provide years of service before replacement or overhaul is necessary. Switch panels are another story. A high quality switch panel will exceed the life of a vehicle with little or no maintenance required. Further, a carefully designed switch panel will provide excellent protection to wiring harnesses and electrical apparatus thereby providing enhanced reliability to the vehicle's electrical system. If a switch panel is improperly designed or constructed, overloads or short circuits will create failures of switch components, relays, solenoids, wiring or circuit breakers. If high current levels are present in circuits, constant overloading will fatigue components in the circuit and eventually result in circuit failures, or worse ... a fire.

Generally, switch panel types are grouped in two categories:

- Switch panels utilizing appliance control switches; and
- Switch panels utilizing magnetic circuit breakers as the switching devices.

Appliance control switch systems have been by far, the most commonly used in switch panels used in state fleet and other service vehicles. A steady move by fleet specifying engineers to design in magnetic circuit breaker switch panels has occurred in the last five years. Citing a significant improvement in reliability and performance, fleet maintenance personnel using magnetic circuit breaker switch panels are focusing on other areas of concern. The following sections will explore the differences in technologies used in the two types of switch panels.

SWITCH PANELS UTILIZING APPLIANCE CONTROL SWITCHES

Commonly identified as having "bat" type toggle levers, panels designed with appliance control switches are functionally adequate; that is, they will perform the task of opening and closing an electrical circuit. Well suited for household use where constant operation requirements and long term reliability are not as crucial as in public works vehicles, appliance switches offer perceived economical advantages over magnetic circuit breaker counterparts. Military approved versions while more robust, still do not offer the protection and long term reliability of magnetic circuit breaker switches.

A typical circuit component layout for electrical apparatus consists of a switch to open and close a circuit, a relay or solenoid to carry the load, a circuit breaker or fuse to protect the circuit, an incandescent indicator light to identify the switch function, and a number of wires connected to each component. Each component and wire connection must be considered a potential trouble point. In the event of circuit failure, trouble shooting multiple components is time consuming and expensive. If the source of the failure is a burned wire, other wires in the same location (loom) may be burned and need replacing. Secondly, the number of components required to operate apparatus in a conventional switch system will increase the electrical resistance of the circuit enough to alter the performance of the appliance. Reliance on multiple components and wires not only presents reliability problems but increases safety risks and trouble shooting problems. Multiple connection points increase the risk of corrosion which ultimately leads to appliance failure. Lastly, original or replacement switch panel installation is both tedious and time consuming.

Appliance type switch panels commonly use incandescent indicator lamps to light each switch function. Again, while functionally adequate, several disadvantages of this technology will lead to more frequent service and replacement intervals. Typically, the indicator's function is to provide visual verification that a circuit is on and the appliance is functioning. Since an appliance switch usually powers a relay coil and not the apparatus itself, it does not know when an overload has occurred. As a consequence, the indicator light which receives its power from the switch continues to operate even when a fault has occurred. There is no provision to visually alert the operator of a fault. Incandescent indicators use the same light source found in the common household light bulb. The light emitting component (tungsten filament) is fragile and is susceptible to failure when vibration is encountered. In domestic use, rarely does a light bulb encounter the vibration and shock conditions that are every day occurrences in service vehicles. While evolutionary design improvements have led to more reliable performance, shock sensitivity still remains a serious concern. Life expectancy of incandescent lamps are dramatically less than solid state counterparts. In best case environments incandescent lamps have a life expectancy of approximately 15,000 to 20,000 hours. A typical vehicle will need indicators replaced every two to three years if vibration or heat related problems do not create a failure earlier in the life cycle.

SWITCH PANELS UTILIZING MAGNETIC CIRCUIT BREAKER SWITCHES

Magnetic circuit breaker switches offer considerable advantages over appliance switch counterparts. Widely used in computer and industrial controller applications, magnetic circuit breakers offer the best possible protection for any application requiring highly reliable circuit protection. With state of the art circuit protection built into the switch, no longer does an installer need to wire a complement of relays, solenoids or circuit breakers for each circuit into the vehicle. Modern switch panels incorporating magnetic circuit breaker switches allow the installer to bring one wire in from the positive side of the battery to a common bus bar on the back of the panel. Installation is completed by routing one wire from each switch function to its designated apparatus. Installation and trouble shooting time, if required, is significantly reduced.

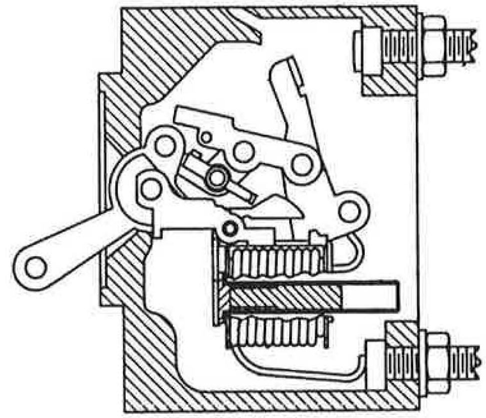

FIGURE 1 Cross section of magnetic circuit breaker.

Perhaps the most important advantage of magnetic circuit breaker switches is their method of circuit protection. Magnetic circuit breaker switches open automatically under overload conditions, see Figure 1. Unlike thermal circuit breakers that use bi-metallic strips to sense thermal changes to trip, magnetic circuit breakers utilize a magnetic time delay system where hydraulic sensing components react only to changes of current in the circuit being protected. As a result, they are considered temperature stable and react instantly to overloads. Temperature stability is critical as magnetic circuit breakers will perform reliably when a vehicle is operated in either cold or warm temperature extremes ... not so with thermal circuit breakers or fuses. Further, magnetic circuit breakers have no "warm-up" period to slow down their response to overloads nor is there a "cool-down" period after overload before they reset.

A highly efficient circuit tripping system provides excellent protection. Mechanically speaking, the tripping mechanism consists of a current sensing coil connected in series with a set of contacts, see Figure 2. As the normal operating current flows through the coil, a magnetic field is created around the coil. When current flow increases, the magnetic field also increases drawing a magnetic core inside the coil toward a set of contacts. When the core is fully energized an armature is attracted to the core,

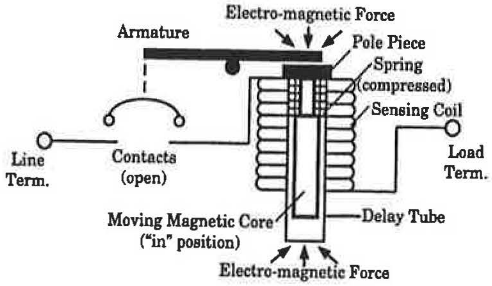

FIGURE 2 Tripping mechanism, magnetic circuit breaker.

unlatching a tripping mechanism, thereby opening the contacts. This process is so efficient that under short circuit conditions the response time to open the circuit is milliseconds. Magnetic circuit breakers are designed to operate up to rated current levels and contain a delay circuit that will allow certain current surges to occur without causing "nuisance tripping." For safety concerns, a trip free mechanism makes it impossible to manually hold the contacts closed during overcurrent or fault conditions. Switches are available in current ratings of 10-50 amps. Actuation is single pole, single throw only.

Dual stage, solid state LED (Light Emitting Diode) back lighting, working in tandem with magnetic circuit breaker switches are a highly effective means of back lighting switch functions. Typical of solid state components, LED's are extremely rugged and have lifetimes exceeding 100,000 hours of operation. Switch panels with LED's mounted into circuit boards should provide trouble free operation beyond the life of the vehicle. Innovative design features allow the indicator system to become a complete visual verification and fault indicating device. Fault indication is a result of the back lighting system wired directly to the magnetic circuit breaker switch. When a fault is detected the circuit breaker trips, the switch actuator moves to the off position killing power to the indicator.

A dual intensity feature allows the vehicle operator to read the switch function when the switch is off and the ignition is on. When the switch is turned on, the intensity of the back lit indicator becomes ten times brighter giving instant verification of a closed circuit. When several switches are mounted in tandem, this feature easily allows the vehicle operator to determine which switches are on.

CONCLUSION

The performance of magnetic circuit breaker switch panels currently used by state fleet and public works organizations has exceeded expectations. Use of this system has dramatically reduced the occurrences of electrical faults in vehicles. Combining durability and safety, fleets are now assured of having the best possible electrical protection available. Vehicles will have fewer maintenance calls and operators are able to drive vehicles with renewed confidence. As a result of performance and reliability successes, an unprecedented lifetime warranty offered by switch panel manufacturers demonstrates the confidence placed in this technology.