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AUTH.NAME AUTHOR AFFILIATION
JOHNSON,W.J. Westinghouse Electric Corp.
RECIP.NAME RECIPIENT AFFILIATION
MURLEY,T.E. Office of Nuclear Reactor Regulation, Director (Post 870411

SUBJECT: Part 21 rept re Westinghouse Class 1E thermal/magnetic molded case circuit breakers performance charcteristics.

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Westinghouse Electric Corporation
Energy Systems
Box 355
Pittsburgh Pennsylvania 15230-0355

January 9, 1990

NS-NRC-90-3481

Mr. T. E. Murley
Director, Office of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Murley:

The following information is provided pursuant to the requirements of 10CFR Part 21 to report the potential for the existence of a substantial safety hazard as communicated by Mr. P. J. Morris and Mr. R. P. DiPiazza of Westinghouse to Mr. C. E. Rossi of the Nuclear Regulatory Commission by telephone on January 5, 1990. This issue concerns the potential for all models and sizes of Westinghouse Class 1E thermal/magnetic molded case circuit breakers' performance characteristics to deviate from published information.

BACKGROUND

Westinghouse supplied 224 molded case circuit breakers from the FB family for Class 1E service for unspecified applications to the Indiana Michigan Electric Company, D. C. Cook Nuclear Station. D. C. Cook personnel informed Westinghouse on November 22, 1989 that they installed one of these breakers in the Turbine Room No. 2 sump pump circuit, a non-Class 1E motor starting circuit, and that the breaker tripped open during attempts to start the motor. Following this occurrence, two other FB3125L breakers were put in the circuit but did not remain closed during the start up of the 75hp motor. After this sequence of events, the suspect breakers were bench tested and found to have lower trip currents than published commercial curves at currents between 300% and 550% of rated current. Representatives from Westinghouse and D. C. Cook performed tests on the breakers at the Westinghouse Distribution & Control Business Unit, Low Voltage Breaker Division, and these tests also confirmed the deviation of these breakers at these currents.

EVALUATION

Thermal/magnetic breakers have maximum and minimum time/current curves included in the published information. These breakers have two trip mechanisms resulting in two distinct portions of the time/current curves. The thermal portion of the minimum curve defines the performance characteristics of the breaker for continuous current for which the breaker will remain closed. The magnetic portion of the minimum curve

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defines the instantaneous current under which the breaker is expected to remain closed. The thermal trip function is caused by a bimetal thermal element being heated by the overcurrent and pushing against the trip bar until the circuit breaker trips. The magnetic trip is caused by increasing flux in the magnetic circuit, produced by high overloads, that will attract the armature and trip the circuit breaker.

The thermal and magnetic trip functions overlap in the region from 300% of rated current to the beginning of the instantaneous portion of the curve. The functions interact in this area because the thermal element pushes against the trip bar and at the same time the magnetic element oscillates against the trip bar, causing the breaker to trip open sooner than the curve indicates. The shape of the published typical curve does not reflect this interaction and, therefore, may not be bounding for all breakers in the specific area. In the application of this breaker, in a motor starting circuit, the breaker needs to remain closed when the motor is starting and running. Westinghouse performs confirmatory tests at two points to demonstrate compliance to the thermal portion of the standard time/current curves and for most breaker families verifies the magnetic trip. Specific electrical confirmatory tests are not performed in the interaction region so the capability of the breaker to remain closed in the interaction area was not verified prior to shipment.

SAFETY IMPACT

Circuit breakers in a typical commercial application have an equipment and personnel safety function. This safety function is to trip on any overcurrent condition before a piece of equipment or conductors are damaged. If the breaker trips quicker than expected, it is a nuisance but still is a safe situation. While the breaker for D. C. Cook was not installed in a nuclear safety related circuit, the breakers were sold as Class 1E breakers. The possibility exists for Class 1E breakers with similar time/current performance to be installed in a safety related circuit at other plants.

Two Class 1E applications where thermal/magnetic breakers are known to be used are in motor and coordination applications. Thermal/magnetic breakers which have been installed in similar motor applications where periodic startup testing has not been performed may trip open and prevent operation of safety related equipment if called upon to start. Where thermal/magnetic breakers are being used for coordination, they should be sized in such a manner that these irregularities in the time/current curves will not affect the coordination scheme or that a premature opening would be conservative. Therefore, the breakers will still perform their intended safety function. If these breakers are installed in Class 1E motor starting circuits, credit must be taken for testing of these breakers. Initial circuit testing and periodic surveillance testing will expose any deficiencies in the circuit breakers if this testing is typical of actual service.

CORRECTIVE ACTION

While the breakers at D. C. Cook have not been bounded by the published performance curves, previous history in both the commercial and nuclear fields does not indicate many other reported instances of this particular behavior affecting a safety function. While other instances of this behavior cannot be ruled out, the lack of other similar reports indicates that such behavior may not be widespread. Westinghouse is notifying all nuclear utilities to verify performance characteristics applicable to their service conditions before the breakers are placed in service. If the breaker is already installed in a motor starting circuit, functional tests of the system is one method for verifying proper breaker performance. If thermal/magnetic molded case circuit breakers are being used for coordination and if the coordination relies on proper performance in the interaction region, it is recommended that those breakers be tested to ensure that their characteristics support the coordination requirements. This testing can be done on site or at the Westinghouse Distribution & Control Technical Center. Although NEMA Standard AB2 has been withdrawn, the guidelines found in the standard are applicable for field testing circuit breakers.

An attachment discussing the applications of thermal/magnetic breakers is included. An information copy of this notification will be forwarded to all nuclear utilities. Westinghouse is actively evaluating this issue to determine what corrective action, if any, may be necessary to preclude recurrence.

If you have any questions regarding this matter, please contact Mr. Pete Morris of my staff at (412)374-5761, or myself.

W. J. Johnson, Manager
Nuclear Safety

ATTACHMENT TO NS-NRC-90-3481

APPLICATION OF THERMAL/MAGNETIC CIRCUIT BREAKERS

Circuit breakers have defined time/current characteristics which reflect both an overload (thermal) function and a short circuit (instantaneous/magnetic) function. The thermal portion defines the amount of time a breaker should take to trip for a given amount of overload. This curve has an inverse time characteristic, typically with an I^2T relationship. The magnetic portion defines the time at which point the breaker will trip with no intentional time delay. To accomplish the thermal characteristic, a bimetallic device is normally employed. For instantaneous tripping, a magnet and armature are normally used. Both interface with the breaker's trip bar to unlatch and trip the breaker for fault conditions. It is not common practice for Underwriters Laboratories or the manufacturers to check trip points at the transition between the thermal and magnetic functions.

The primary function of a thermal/magnetic molded case circuit breaker is the protection of conductors and specifically the conductors' insulation. Thermal/magnetic circuit breakers are not the first choice for the protection of equipment, such as motors. Other devices are specifically designed to provide this protection. In any case, it is important that the breaker always have a trip characteristic whereby the breaker opens and trips before the conductor and/or its insulation is damaged.

The possibility of molded case circuit breakers not having enough margin when being used in motor circuits could constitute a safety concern provided no startup tests were performed on the equipment or if no periodic surveillance testing was conducted. A wide range of transient inrush current profiles are possible based on the closing angle in each phase, the position of the motor's armature with respect to its stator, the motor's air gap, its armature and stator construction, the magnetic materials, and its copper and stray load losses. Each time a motor is started, its inrush may vary over a wide range due to these conditions, and consequently, the worse case transient will not necessarily occur each time. If a thermal magnetic breaker must be used in a motor application, it should be sized taking advantage of the exception to the the National Electric Code which allows thermal/magnetic breakers to be sized up to 400% of full load current. Critical applications that require a higher immunity to nuisance tripping should be designed with a higher margin between the transient starting profile of the motor and the profile of the protective device. In installations where motor starting and running is paramount, consideration should be given to the use of special circuit breakers with special trip calibrations. Westinghouse recommends the use of MCPs or magnetic only breakers in conjuction with overload relays in lieu of thermal/magnetic breakers for motor starting circuits. In cases where very precise tripping of the branch circuit protective device may be required over a wide range of currents, other devices such as protective relays, should be used in conjuction with a molded case circuit breaker.

Time/current curves of molded case circuit breakers are provided for the purpose of determining the coordination of circuit breakers to other devices, such as other circuit breakers, fuses and overload relays, in a distribution system. In circuit breakers rated at 150 Amps or less, the time/current characteristic is fixed. Circuit breakers rated at above 150 Amps have the ability to adjust the time/current characteristic for different pickup and time delay values. Time/current curves typically available from the manufacturer are family curves and are not specific to a given amp rating. These are "typical" time/current curves for specific environmental conditions, such as those used for fuses and do not depict the trip points of individual circuit breakers with absolute accuracy.