
Issue 114: Seismic-Induced Relay Chatter (Rev. 1)

DESCRIPTION

Historical Background

This issue was identified in a RRAB memorandum¹ in March 1985 and addressed the possibility of relay contact chatter during a seismic event and its resulting effect upon safety and safety-related electrical control systems and their abilities to provide for and maintain a safe plant shutdown.

Various regulatory requirements address seismic design requirements and definitions. These include, but are not limited to: 10 CFR 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants"; SRP²

Sections 2.5.1, 2.5.2, and 3.10; Regulatory Guide 1.29³; and Regulatory Guide 1.100.⁴ NRC regulations require a nuclear plant to withstand the effects of an SSE and to assure: (1) the integrity of the reactor coolant pressure boundary; (2) the capability to shut down the reactor and to maintain it in a safe condition; or (3) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposure. The SSE is defined as that earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geological and seismological and specific characteristics of local subsurface material. It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. Of concern is the capability of relays to perform at the SSE. For earthquakes which exceed the SSE (a low probability event), the ability to assure a margin for relay chatter is sought.

The RRAB memorandum⁵ identified a number of activities which address aspects of this issue. These include:

(1) the NRC contract with Future Resource Associates, Inc., which is investigating whether seismic PRAs can be improved by detailed analyses of equipment failures and operator-responses; (2) Seismic Design Margins Program which is to determine the seismic margins in the existing plants in the eastern United States; and (3) Issue A-46 which addressed the seismic qualification of equipment in operating plants. As part of Issue A-46, there are efforts for the evaluation of the qualification test adequacy of relays required to be functional to assure safe plant shutdown and for the collection of fragility data by the Seismic Qualification Utility Group. Currently, there is a review group within NRC, supported by a corresponding industry group, working on the criteria for determination of relays that are needed to perform during a seismic event.

Safety Significance

A large number of relays are used to control many devices in nuclear power plants such as pumps, valves, and circuit breakers. In addition, much of the control logic for system initiation and control is accomplished with relays. Relay control may be accomplished by relay actuation either in the energized or the deenergized state.

¹ Memorandum for W. Minners from A. Thadani, "Seismic Induced Relay Chatter Issue," March 22, 1985.

² NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, (1st Ed.) November 1975, (2nd Ed.) March 1980, (3rd Ed.) July 1981.

³ Regulatory Guide 1.29, "Seismic Design Classification," U.S. Nuclear Regulatory Commission, June 1972, (Rev. 1) August 1973 [8003280778], (Rev. 2) February 1976, (Rev. 3) September 1978. [7810030052]

⁴ Regulatory Guide 1.100, "Seismic Qualification of Electrical Equipment for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, March 1976, (Rev. 1) August 1977.

⁵ Memorandum for W. Minners from A. Thadani, "Seismic Induced Relay Chatter Issue," March 22, 1985.

Seismic-induced relay chatter is the opening and/or closing of relay contacts due to the influence of seismic accelerations either directly or indirectly. It is possible that this phenomena may result in important equipment being rendered inoperable as well as the loss of systems status indications. Valves may be erroneously opened or closed, pumps may be shut off, diesel generators may be rendered inoperable, etc. Operator actions, not only in the control room but also at various locations in the plant, may be required to realign relays and control circuits to restore required systems to an operable configuration and maintain core cooling. Reactor trip is very likely to result from causes other than relay chatter.

PRIORITY DETERMINATION

Quantification of the risks resulting from seismic-induced core-melt accidents involves a large amount of uncertainty. These uncertainties include a large variation in the estimate of recurrence frequency of seismic events and also in the predicted seismic fragility. The majority of the fragility prediction data employed in performing PRAs is based upon expert judgment; very little is based upon actual test results. Not only is there a large uncertainty associated with fragility data but also the peak amplitude of motion experienced by a

component may vary with changes in the frequency character of the seismic input resulting from the frequency

response of the mounted structure such as cabinets, panels, etc. NUREG/CP-0070⁶ provides insights into the many uncertainties associated with performing PRA-type analyses of seismic events.

In addition to the previously described uncertainties, the response of relays to seismic acceleration has large variations depending upon the relay design (type, size, structure), the state (energized or de-energized), the frequency spectra of the input motion, and the magnitude of the input motion. It has been found that relay response is non-linear, i.e., the fragility does not necessarily decrease with increases in input frequency or acceleration.

Further, the effect of relay chatter is very dependent upon the dynamic response characteristics of the circuit in which the relay contacts are employed. Circuits with fast time constants or response may be very sensitive to relay chatter while circuits with slow response characteristics may not be perturbed by relay chatter.

Issue A-46 provided insights into the effects of relay chatter from seismic events and identified systems whose performance may be degraded by relay chatter.

Further, it determined the effect of relay chatter upon these required systems and develop the procedural guidelines, including human responses, to mitigate these effects.⁷ Most important, the results of Issue A-46 will assure that the systems required to bring the plant to a safe shutdown are not disabled by relay chatter.

CONCLUSION

For greater than SSE events, the Seismic Margins Program and the related programs to collect fragility data address relay capability. Relay performance at the SSE level was covered in the resolution of Issue A-46.

⁶ NUREG/CP-0070, "Proceeding of the Workshop on Seismic and Dynamic Fragility of Nuclear Power Plant Components," U.S. Nuclear Regulatory Commission, August 1985.

⁷ NUREG-1030, "Seismic Qualification of Equipment in Operating Nuclear Power Plants," U.S. Nuclear Regulatory Commission, February 1987.

