Seismic Evaluation of Relays for the Plant Hatch Seismic Margin Assessment

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INTRODUCTION

A major portion of the effort required for a Seismic Margin Assessment (SMA) is an evaluation of the potential effects of electrical relay and contactor chatter. The Electric Power Research Institute (EPRI) is currently sponsoring an SMA of Plant Hatch Unit 1 along with Georgia Power Company (GPC), the owner and operator of Plant Hatch. The objective of this paper is to describe the procedures used to assess Plant Hatch relays and contactors for chatter along with the results of this assessment to date.

Plant Hatch is a General Electric Boiling Water Reactor - Four with a Mark I Containment located on a soil site. The plant was placed in commercial operation in 1975 and is located on the Altamaha River near Baxley, Georgia. The SMA is being implemented by Southern Company Services, Inc. (SCS).

The Plant Hatch SMA relay evaluation is being performed in two phases. Phase 1 was completed in October 1988 prior to the Seismic Capability and Relay Walkdown. Phase 2 is scheduled for completion in June 1989. The results of the SMA relay evaluation are also being used to resolve USI A-46 for Plant Hatch Unit 1. The specific steps involved in the evaluation are shown in Figure 1.

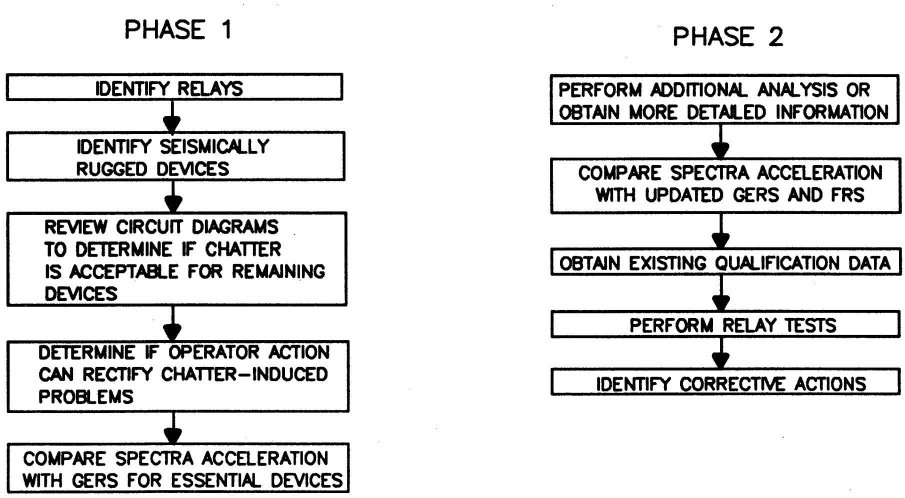

FIGURE 1

PHASE 1 EVALUATION - METHODOLOGY

The primary purpose of the phase 1 evaluation was to screen out as many relays as possible, as quickly as possible. Any relays that could not be easily screened out during phase 1 were left unresolved until phase 2. The following sections described the steps involved in the phase 1 evaluation.

Identification of Relays

The first step in evaluating Plant Hatch relays is to identify the relays required for the SMA success path components. A success path (EPRI 1988) is a set of frontline and support systems capable of establishing and maintaining a long-term safe shutdown condition following a seismic margin earthquake (SME). Two independent success paths were developed by SCS mechanical and electrical engineers. A listing of all components associated with these paths was entered onto a dBASE III PLUS computer file and referred to as the Safe Shutdown Equipment List (SSEL). This SSEL also meet all requirements for USI A-46.

The first step towards identifying relays required for the success paths was to identify the control elementary drawing for each component and enter the drawing number on the SSEL. All electrical devices with contacts were then tabulated for each active and passive component. These devices included control switches; pressure, level, flow, temperature, and limit switches; contactors; and relays. Devices were identified for passive components to ensure that they would not inadvertently change state. Each device was identified by plant identification number, panel number, vendor name and model number, and reference drawing. The complete model number was not listed originally but was added later for some relays if it was required to determine the seismic ruggedness of the relay.

The tabulation of relays for the diesel generators took more effort than the other systems due to the complex circuit schemes involved. SCS resident diesel experts had to be consulted several times during this process.

The relay tabulation was entered into a dBASE III PLUS computer data base. Setting up the data base and entering the information took a considerable amount of time but it proved to be a good choice because of the time saved keeping the data current for the evaluation team. The data base can be sorted by panel, relay vendor and model number, status, relay identification number or component.

Screening Process

The initial step of the screening process was to identify all items that are known by experience (EPRI 1987b) to be seismically rugged (e.g. solid state relays, mechanically actuated contacts, etc.).

The next step involved a review of the elementary diagrams by system to determine if chatter is acceptable for the relays affecting each component. This was determined by resolving the following questions:

- Do any of the spurious actuation possibilities of the relay result in an unacceptable (failure to perform safe shutdown function) malfunction of the system, subsystem or component being examined?

- Do any of the spurious actuation possibilities of the relay result in unacceptable seal-in or lockout functions?

If a relay could not be screened out as chatter acceptable, it was reviewed to determine if operator action could rectify chatter-induced problems. Operator actions are considered acceptable if they are addressed in the existing Plant Hatch operating procedures.

If a relay failed to be screened out by these methods it was classified as an essential relay and evaluated for seismic adequacy as described in the following section.

The first step of the relay evaluation procedure suggested by EPRI (1988) is to check existing seismic qualification data. This data was not readily available in most cases for Plant Hatch. Therefore, this was not a viable first step.

GERS Evaluation

The seismic adequacy of essential relays was determined by comparing the in-panel seismic demand for the relay with the appropriate Generic Equipment Ruggedness Spectra (GERS). Relay GERS were developed by the Electric Power Research Institute (EPRI 1987a). GERS are defined as "the response to input motion at the base of the support point for which equipment of a given class has been demonstrated, on the basis of test experience, to have sufficient ruggedness to perform as required." During Phase 1 of the evaluation, the GERS were subject to change due to vintage issues being investigated by EPRI at that time.

For the phase 1 effort, preliminary relay GERS and estimated required response spectra (RRS) were used to perform a seismic screening of those relays that were not screened out by the system screening effort. A final verification of the seismic screening using the latest relay GERS and the final floor response spectra (FRS) following the EPRI procedures (EPRI 1988) was performed as part of the phase 2 effort.

A Lotus 1-2-3 computer file was developed by the seismic engineers which listed all the relays by manufacturer and model number along with their corresponding GERS value. The relevant buildings and floor elevations were listed across the top with their corresponding RRS value. Lotus 1-2-3 was set-up to automatically compare the GERS value with the RRS value and print the results.

For the Phase 1 evaluation, if a relay failed to meet the GERS in any condition (e.g. energized, de-energized, normally open, normally closed, etc.) for a given plant location, it was deferred to phase 2 for further analysis.

PHASE 1 EVALUATION - RESULTS

The Control Rod Drive and Reactivity Monitoring Systems were screened out by evaluating the effect of relay chatter on the system as a whole. This process took very little time and a significant number of relays were resolved.

Most of the other systems consisted of pumps, valves, and other components that had to be evaluated on an individual basis. In most cases it was easy to show that chatter was acceptable. In other cases operator action would alleviate the problem, for example, chatter may leave a valve in the wrong position, but by operating a switch in the control room the valve could be properly positioned. Some components were affected only by the relays that affect its power source. The evaluation of power sources were a particular problem due to their complexity and the fact that there were a lot of essential relays that did not have qualification data. The power sources consist of the diesel generators, the switchgear busses it supplies power to and the tie to off-site power. Most of the circuit schemes were dependent on each other, therefore, one device without qualification could affect several other schemes. The power sources were evaluated in depth in phase 2 of the evaluation.

A particular relay may be required for several different components. Each of these combinations of relays and components were evaluated. Therefore, the evaluation results will be given in terms of relay combinations for this paper. Approximately 1400 manhours were expended for phase 1. The results of the phase 1 evaluation are shown below:

Status	Number
Chatter Acceptable	1133
Seismically Acceptable	176
Operator Action Required	2667
GERS	242
Additional Analysis Required (Phase 2)	309
Walkdown Information Required (Phase 2)	12
Total	4539

RELAY WALKDOWN

A walkdown of essential relays was performed in conjunction with the seismic capability walkdown of equipment in October 1988. The relay walkdown was conducted by both seismic and electrical engineers. The purposes of this walkdown were to:

- Spot check relay mountings
- Spot check relay types and locations
- Gather information on relay locations within the cabinet along with the dimensions and thickness of mounting plates that support essential relays not currently screened out using GERS.

To perform and document the relay walkdown, an additional sheet was added to the Screening and Evaluation Data Sheets used during the walkdown for all items containing essential relays. This additional sheet addressed the three items mentioned above. Sketches of relay locations and mounting details were done on a separate sheet and attached to the forms. The relay location information was obtained to assess the possibility of using a cabinet amplification factor less than six for comparison with the GERS if necessary.

As a result of the relay walkdown, 44 relays were identified as open items because either the relay could not be located in the listed panel or the vendor name and model could not be identified. Further review of vendor drawings and other plant documents led to the resolution of these open items during phase 2 of the evaluation. This review process revealed that some of the relays were actually seismically rugged devices (e.g. solid state relays) and, therefore, did not have to be located. Others were listed in the wrong location. Several items were identified as devices other than relays (e.g. solenoids) that will not chatter.

PHASE 2 EVALUATION - METHODOLOGY

The purpose of phase 2 of the relay evaluation is to perform a more in-depth analysis of each relay not screened out during phase 1 until a resolution is obtained for every relay. This also includes the resolution of relay walkdown open items. The following steps comprise the phase 2 methodology:

1. Review relay information for accuracy. Inaccurate information could cause problems that are easily resolved. For example, a device identified as a relay may actually be a mechanically operated switch which is considered seismically rugged.

2. Perform a more detailed system response analysis to show chatter is acceptable.

3. Check relays against GERS using final SME FRS values and up-to-date GERS values. A preliminary copy of the GERS that were revised to reflect vintage issues were obtained from ANCO Engineers, Inc. Determine the normal condition of the relay (e.g. energized, normally open) if required.

4. Identify any existing relay qualification data for unresolved relays.

5. Justify a lower, more realistic seismic demand for comparison with relay GERS for specific relay panels. An amplification factor of six was used originally for relay panels. This can be lowered by determining the actual frequency of the panel and relay location in the panel.

6. Work with EPRI to develop relay GERS for Plant Hatch relays not presently covered by GERS.

7. Determine required plant modifications such as; circuit modifications, relay relocation, relay replacement, or procedure changes for essential relays that can not be qualified.

PHASE 2 EVALUATION - RESULTS

The phase 2 evaluation was broken down into two groups of relays. The power sources were identified as one group and the remaining components were put into the second group.

The seismic screening had to be redone using the latest version of the relay GERS and the final SME FRS. An amplification factor of 6 times the FRS was used to obtain the RRS at the relay mounting location. The maximum peak spectra acceleration of the RRS was compared to the maximum spectra acceleration of the relay GERS using the acceptance criteria per the methodology (EPRI 1988) that states that over any 20% frequency bandwidth, the average ratio of the GERS to the RRS should exceed a factor of 1.3 or more. Due to the fact that equipment natural frequencies at Plant Hatch are above about 5 HZ and usually above 8 HZ, the maximum spectra acceleration of the RRS was determined in the frequency range of 5 HZ and above.

The power source evaluation, due to its complexity, was started first. The evaluation was performed assuming loss of off-site power and also for not losing off-site power. The power source circuits were broken down into schemes on the elementary diagrams. The analysis was performed for diesel 1A and considered representative for diesels 1B and 1C.

The power source schemes often had relay contacts in several schemes and the status could be different for each contact. Some schemes were subject to several possible modes of failure. Chatter can interfere with interlocks between 4160V and also 600V supply breakers which may cause equipment damage.

The generator and bus protective relays were a particular problem. It was sometimes difficult to determine the vintage for some relay types for GERS comparison. The diesels have vulnerable relays (i.e. relays that are known to chatter at low seismic levels) and many relays without GERS or test data. The problem areas were identified and a concentrated effort was made to resolve these issues. Corrective action will be required on some relay types.

The diesel generator excitors were also a problem because relay chatter may result in equipment damage or blown fuses. The relays and contactors involved must be seismically qualified to protect this equipment. Since no GERS exist and no qualification data could be located for these relays, they must be tested or replaced.

There were 248 relay combinations associated with the power sources. For 150 of these, either chatter was determined to be acceptable or operator actions can be used to rectify the chatter-induced problem. There are 83 combinations that have not been resolved at the present time. These 83 unresolved combinations involve 66 relays consisting of various different relay types. SCS is currently working with EPRI to initiate GERS testing of these relay types. The remaining 15 power source relay combinations consist of 15 relays that are known to require correction by GPC.

There were 15 non-power source components, affected by 61 relay combinations, identified as problem areas in phase 1. GERS, along with additional system analyses, were used to resolve eight of these relay combinations. The remaining 53 relay combinations were resolved using existing seismic qualification data. The phase 2 evaluation has expended 850 manhours to date.

SUMMARY

The SMA relay procedure (EPRI 1988) does work, however, it must be adjusted to fit individual plant documentation levels (e.g. lack of relay qualification data). The 2250 manhours expended to date on the relay evaluation is a major portion of the Plant Hatch SMA project. Some of this time was spent developing procedures at the beginning of the evaluation that fit the specific conditions existing at Plant Hatch. Whenever a relay failed to pass the normal screening procedures, a more in-depth evaluation was performed. This often required innovative thinking by the engineers. Some effort was also lost due to the GERS and the SME FRS changing during the project. Other plants should be able to perform this evaluation using fewer manhours by utilizing the experience gained on the Plant Hatch SMA along with the finalized procedures and GERS.

REFERENCES

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