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NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

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MEMORANDUM FOR: Dr. D. Okrent, ACRS Member

FROM: Mr. J. MacEvoy, ACRS Senior Fellow

SUBJECT: Control Room Indications During and Following Earthquakes

Introduction

In early December you asked me to think about nuclear power plant non-safety system failures during an earthquake and the confusion that might be caused in the control room due to the ensuing alarms and abnormal indications. In discussing this question with members of the NRC Human Factors Staff and friends in the nuclear industry I've come to the conclusion that a lengthy, detailed analysis of specific plant system performance is required to quantify this problem. However, viewing the problem qualitatively can be very informative, which is what I've done to date.

Discussion

There are several non-safety related systems whose alarms and parameters indicate on the panels facing the control room operator. These systems include electrical distribution, turbine and lube oil, feed and condensate, building ventilation, non-safety related component cooling, main circulating water, etc. There are several and they constitute a significant percentage of the panel display area. It's safe to assume that during a severe earthquake many, if not all, of these non-safety systems will fail or be perturbed into abnormal operating conditions resulting in alarms and erratic indications in the control room. This would result in control room operator confusion both during and after the earthquake. Operator response during the active period of the earthquake is probably not worth considering, very few instruments, whether safety or non-safety related, will be indicating properly, nor will the control room operator be overly concerned with plant response. The plant may SCRAM during the earthquake due to a Turbine Generator trip. After the earthquake has subsided the control room operator will probably silence all alarms and select the most important for action. This will be a difficult task unless he's very familiar with the various alarm panels. Once he's selected the alarms of interest he must find the appropriate reliable instrument to provide operating data for decisions and corrective action.

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By having a whole forest of actuated alarms the operator loses his sense of "related alarms", that tells him the real nature of the problem(s) being experienced. For example, a reactor SCRAM accompanied by a turbine trip and tripped generator output breakers is a totally different situation than a SCRAM with a tripped turbine and a low condenser vacuum alarm. When faced with several alarms the operator must analyze each and reject those not contributing information to the most urgent malfunction.

At least one U.S. plant has taken steps to make the problem more manageable. Its control room uses seven alarm display colors to indicate the importance of each alarm. The system used is:

1. Dark red faceplate for reactor automatic and manual scrams

2. Pink backlight for:
   a. Safety related system actuated
   b. Safety related system loss of power
   c. Fire detected
   d. Radiation high-high
   e. Nuclear Steam Supply Shutoff System manual isolation

3. Amber faceplate for safety system degraded alarms

4. Amber backlight for:
   a. Safety related system faulty test
   b. Radiation high
   c. Neutron monitoring system alarm
   d. Fire protection system lockout

5. Light green backlight for:
   a. Safety related system in test status
   b. Remote shutdown switch in emergency
   c. Safety related system trip bypass
   d. Mode switch shutdown scram bypassed
   e. Low condenser vacuum bypassed
   f. Fire protection system actuated (CO_2 or Deluge)

6. Blue faceplate for future assignment

7. White faceplate for all other alarms

Unfortunately the above types of systems are not in common use, since they do seem useful in prioritizing alarms for the control room operator.

A second prioritizing system, selective muting of alarms, could provide benefits in reducing control room confusion, and is being used by the Swedish State Power Board at Forsmark and Ringhals. Sandia labs is supposedly preparing specifications for a demonstration system at a U.S.

nuclear plant, however I could not confirm this by discussions with the NRC Human Factors staff. One shift supervisor with whom I discussed this system thought it would significantly simplify the control room operator's job of analyzing serious accidents. Based on my experience with a large break LOCA at the GE simulator, I agree with that opinion.

One generic innovation that will assist the operator during a catastrophic event is the Safety Parameter Display System. The operator can go directly to this panel which will serve to filter out the extraneous, unreliable indications, and provide those needed to make important operating decisions as to the overall status of the plant.

Conclusion

A quantitative answer to the question, "What confusion is created in the control room due to non-safety related system failures during an earthquake" is not easily answerable without performing a tedious plant specific study. In the opinion of the NRC Human Factors Branch, due to the possibility of multitudes of alarms, the control room operator will probably have difficulty sorting out important from less important events following a major earthquake. The Safety Parameter Display System should be of some use by indicating whether the reactor is in a safe condition or not, however, if not in a safe condition, the control room operator will still need to wade through alarms of varying importance, accepting or rejecting them as necessary.

The post-accident confusion concern was sufficient for at least one U.S. plant and a foreign power board to prioritize their alarms.

Recommendations

1. Follow up with Sandia Labs to see what work they are doing or have done in this area. They are involved in at least one alarm prioritizing project using color coding.

2. Question the Swedish State Electric Power Board as to why they developed their priority muting system. A comprehensive study on post-earthquake control room conditions may have been done prior to developing their selective muting system.

cc: ACRS Members
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