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February 27, 1980

Mr. E. Igne, Staff Engineer
U.S. Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards
1717 H Street, NW
Washington, DC 20555

Dear Mr. Igne:

Comments on Meeting of ACRS, Subcommittee on
Plant Arrangements, Afternoon at February 21, 1980

Enclosed are my comments on the subject meeting.

Yours very truly,

Everett Rodabaugh

E. C. Rodabaugh
Applied Solid Mechanics Section

ECR:cw

cc: Myer Bender
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Comments on
Meeting of ACRS, Subcommittee on Plant Arrangements,
Afternoon of February 21, 1980

by

E. C. Rodabaugh
February 27, 1980

The five items discussed during the afternoon were:

(23) Quality Group Classification for Pressure Retaining Components

(22) Seismic Design of Steam Line

(28) Protection Against Pipewhip

(41) Seismic Category 1 Requirements for Auxiliary Systems

(73) Vessel Support Structures

The status/progress on each of these items was presented by R. Bosnack of NRC staff. Considering the complexities of the aspects involved, it appears to me that NRC staff is evaluating these aspects with due care and that nothing would be gained in safety of nuclear power plants by attempting to speed up their evaluations.

I would like to make some general comments concerning the items addressed at the meeting; to do so I group the items into (23), (22), (41) as related to seismic design; (28) and (73) as related to postulated pipe breaks.

Items (23), (22) and (41), Seismic Design

Item (23), "Quality Group Classification" is not necessarily the same as seismic design classification; however, any upgrading in Quality Group might be accompanied by changing from non-seismic to seismic. Accordingly, I view all three of these items as related to the question: How much emphasis should be placed on seismic design of piping in nuclear power plants?

If piping systems could be designed for severe earthquakes in such a manner that there would be no undesirable effects on the piping system due to the seismic design, the answer to the question would be simple. Yes, design all essential piping systems for severe postulated earthquakes. Unfortunately, it appears that undesirable effects are introduced by designing for severe earthquakes. In many designs, additional restraints and snubbers are added for the sole purpose of seismic restraint. Undesirable side effects are:

- Snubbers may "lock-up" and thus place undesired (and unanticipated) loads on the piping during normal operation
- Snubbers (and their ties to the pipe and snubber supports) may intefer with in-service inspection
- Where snubbers or other restraints are attached to the pipe through welded-on lugs or trunions, these welded-on attachments introduce stresses in the pipe pressure-boundary and are potential crack sources.

In addition, I am concerned that there may be a more subtle "side-effect" in seismic design. We would all like to think that, when it comes to assuring safety of nuclear plants, our resources are unlimited. I doubt whether this condition really exists; in particular with respect to skilled engineering manpower. To illustrate my concern: With respect to a hypothetical nuclear power plant in Louisiana, which of the following two allocations of engineering manpower would be more effective in increasing the safety of the plant?

(a) Assign X engineering hours to review locations of drains in the main steam line and operating procedures to assure that slug-flow of entrapped water in the steam line is very unlikely.

(b) Assign X engineering hours to conduct a seismic analysis of the steam line, with due concern as to how the ground motion is changed by the building/piping supports, mass points used in the piping system model, damping factors, how the earthquake responses are combined, etc, etc.

If a choice had to be made, in my opinion (a) would contribute more to the safety of the plant than (b).

A disconcerting number of cracks have occurred in nuclear power plant piping. I say "disconcerting" because I view any interruption in the smooth operation of a nuclear power plant as a potential safety problem. These have occurred due to such causes as stress corrosion cracking, vibration (of small lines), water hammer (slug flow), relief valve thrust or cyclic thermal stresses. As far as I am aware, no damage has occurred to piping in any nuclear power plant in any country due to earthquakes.

The other side of the coin, however, is what would happen to the piping in a nuclear power plant if a severe earthquake did occur at the plant site. Because, apparently, no such event has happened a direct answer is not available. However, there have been a number of severe earthquakes at sites of fossil fueled power plants, refineries and chemical plants. What happened to piping in those plants?

R. L. Cloud made a start at answering the question. His report, "Seismic Capability of Nuclear Piping", May, 1979, was (I believe) presented to the ACRS at a meeting on July 10, 1979. The following is quoted from the conclusion of that report.

> "All available data on the actual seismic performance of power piping systems were reviewed. It was shown that operating power plants do indeed have very high levels of seismic capability. Of the several plants that sustained severe ground motion from 0.2 to 0.6 g there were no failures of welded steel power piping. In one case a steam drain line was reported broken by differential movement, and this was the only instance of breached integrity found. Considering the magnitudes of the earthquakes and the variability of the design practices, this is an excellent record and can only have been made possible by the natural resiliency of power piping."

Cloud's report, I suspect, was prepared under tight time/costs restraints and I do not consider the report as an adequate answer to the question: What happens to piping during earthquakes? Nevertheless, it is a starting point and members of the ACRS might wish to reread pages 15-26 of Cloud's report.

I do not want to convey the impression that answering the question, "What happens to piping during an earthquake", is an easy or simple task. As anyone who has tried to gather and evaluate "field experience" knows, there are many frustrations, blind alleys and incomplete answers. To give an idea of how I view the magnitude of the task, I would contemplate a budget of $250,000 and an intensive effort over a one year period.

In my opinion, an NRC task to evaluate what has happened to piping during earthquakes would be more useful to ACRS perspective of the subject than any ongoing NRC program on seismic evaluations. While I am not aware of the present scope of the NRC program on seismic evaluation, I get the unhappy (and hopefully incorrect) impression that the results will lead to conclusions like "Computer Program A will do more (or easier, or faster) than Computer Program B". What I would like to see is a conclusion like "Computer Program A more accurately predicts what actually happens during an earthquake than computer Program B". To make such a conclusion, one must have information on what did happen; e.g. what broke and what did not break.

I have talked about piping in the preceding but, it seems to me, one may find relevant information on what happened to pressure vessels, pumps, valves, instruments, etc. during earthquakes.

As a final aspect of my comment on seismic design, let me broaden the scope and ask: What happens to piping when it is subjected to severe dynamic loads from any source? Information exists, from nuclear power plants as well as other plants, as to what happens from water hammer, slug-flow, turbine trip, etc. However, the particular data I am interested in was perhaps developed by the U.S. Navy in connection with shock tests of nuclear-powered submarines and aircraft carriers. I recognize the "classified" aspects of such data (if they exist) but it seems to me that the data might be abstracted in non-classified form so that it would provide valuable perspectives on what is critical. In our various paper-analyses, are we looking at things that are least-likely-to-fail and missing those things that are really critical? I would suggest, if it has not already been attempted, that ACRS request NRC staff to see if such data might be made available. Possibly such data might also be relevent to what happens to pressure vessels, pumps, valves, instruments, etc.

Items (22) and (73), Postulated Pipe Breaks

As in seismic design, if there were no undesirable "side-effects" I would view installation of pipe whip restraints as an appropriate precaution in nuclear power plants. Unfortunately, I see the same undesirable side-effects in postulated pipe breaks as discussed previously for seismic design.

We are accustomed to describe nuclear power plants as having "defense in depth". Let me introduce another line of defense; the leak-before-break concept. If we could have a high degree of assurance that a detectable leak would always occur prior to a break, and sufficient time between leak-detection and crack-growth to a break size exists for shut-down, then it would not be necessary to postulate pipe breaks. Pipe whip restraints, with their undesirable side-effects, might be eliminated. We would still have the relatively minor aspects of what gets sprayed or dropped on by the leak and much smaller problems of flooding of compartments.

During the meeting, we touched on two aspects of the leak before break concept

(1) Can we further bolster our (already good) leak detection systems? The possibility that sound monitors might be used struck me as a potentially feasible adjunct to present leak detection systems, based on my experience with high pressure lines in general where, quite often, a leak is first detected by hearing it; not seeing it.

(2) Is there any place in a piping system where a crack might not leak because the fluid cannot get to the crack? The Duane Arnold recirculation inlet nozzles were an example of this potential problem.

With respect to the first aspect, I understand NRC staff is working on it and should be encouraged by ACRS to continue that work. I would also like NRC staff to think about other feasible ways to bolster leak detection systems. As a wild idea to stimulate such thinking, I used to detect the first few drops of water leakage in fatigue tests by using two closely spaced wires in a blotter soaked with salt solution and then dried out. A few drops of water decreased the electrical resistance between the wires and operated a switch. Can something like this be developed to work at 550F? If so, would it be useful to install such a device between the pipe and insulation at highly critical weld joints so as to detect leakage of a few drops rather than 1 gpm?

With respect to the second aspect (sealed cracks), it is not apparent to me that NRC staff has recognized the potential seriousness of this kind of design detail with respect to the leak-before-break line of defense. If, indeed, this is the case, I would like to see NRC staff in OL reviews ask the applicants whether there is any place in their piping systems where a "sealed crack" might exist and, if so, what they propose to do about it (e.g. increased in-service inspections).

The entire area of in-service inspection is, of course, closely related to the aspect of finding cracks before they develop into either a leak or a break. Also, the field of fracture mechanics as applied to ductile materials is relevant to crack growth rates and whether the crack will leak before it breaks. However, these are areas which NRC staff are vigorously pursuing and I have no suggestions, at present, other than to continue that pursuit.