Sandia National Laboratories

Albuquerque, New Mexico 87185

date: September 13, 1982

to: Containment Integrity Peer Review Group

from: Walter A. von Riesemann - 9442

subject: Peer Review Group Meeting, Quality Inn, Arlington, Virginia, June 9, 1982

Enclosed are highlights from the subject meeting. Also enclosed is a letter describing the large-scale steel model, dated May 3, 1982.

WAVR:9442:jp

Copy to:
J. Costello, NRC
J. Burns, NRC
W. Anderson, NRC
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File 1047.011

(17)

September 13, 1982

Minutes of Peer Review Group Meeting, Quality Inn, Arlington, Virginia, June 9, 1982

Attendance

Peer Review Group

Thomas J. Ahl, Chicago Bridge & Iron
Richard S. Denning, Battelle Columbus Laboratories
Asadour H. Hadjian, Bechtel Power Corp.
Mete A. Sozen, University of Illinois
John D. Stevenson, Stevenson & Associates
Y. K. Tang, for Ian Wall, Electric Power Research Institute
Joseph J. Ucciferro, United Engineers & Constructors, Inc.
Richard N. White, Cornell Univerrsity
James S. Wilbeck for Alfred E. Baker, Southwest Research Institute

NRC

John Burns
James Costello

Sandia

Thomas E. Blejwas
Albert W. Dennis
Daniel S. Horschel
Joseph Jung
Wayne A. Sebrell
Walter A. von Riesemann
Ronald L. Woodfin

Guest

Peter Cybulskis, Battelle Columbus Laboratories

NOTE

Rather than transcribe the recorded discussion, the comments made at the Peer Review Group Meeting were collected by subject matter.

1. Discussion of Program Direction

On June 8, 1982, at the close of the day's session of the "Workshop on Containment Integrity", an informal discussion was held between Prof. Chester Siess; the Sandia Peer Review Group; William Anderson, John Burns, James Costello, NRC; and the Sandians.

At an ACRS subcommittee meeting on the containment program in Albuquerque (March 22, 1982), Siess identified four failure modes for containments. They are:

1) failure to isolate

2) failure of isolation valve or penetration following an accident

3) failure of penetration/door due to excessive deformation

4) rupture of the containment

Siess also suggested at that meeting that there should be an emphasis on looking at penetrations. In addition, he raised a question on whether the sequence and/or the number of small scale steel models is right. He also suggested that the program be more agressive and leap-frog ahead and test a model which is as large as is practical and has as many features on it as possible. Siess repeated these points to the Peer Review Group at the informal meeting on June 8. In addition, he mentioned that the NRC research budget is not growing. There was a brief discussion of these topics on June 8; however, most of the discussion occurred the next day, June 9, 1982, during the Peer Review Group Meeting.

The Peer Review Group discussed the overall program in light of the points raised by Siess. A review of this discussion follows.

Sozen stated that originally there was a minority opinion that one should pressurize the largest scale specimen that one could build economically and make it as close to standard fabricating practice as possible and include all the bells and whistles that one could reasonably put on. If there is a surprise, then there is something to deal with. He felt this is what Siess meant.

Costello recognized this point, but as a practical matter, what we are going to do on the steel containments is pretty much set, except for details. (see Section 3.) The work on concrete containments will consider the points that were raised by Sozen. Originally, in the program plan, three factors were used in the decision to use small and large scale models. These were: a) to gain "batting-practice", i.e., get loads on a structure, and measure response on the least inexpensive model possible; b) to build up computational expertise in steps; c) to determine if there are any scaling effects. However, budget restrictions did not permit the original plan to be fully implemented.

In regard to "leap-frogging", it was agreed that this would be done with the concrete model and not the steel.

Stevenson stated that the Commission may have a misperception about containment integrity. The pressures quoted have dealt with containment strength and not with the pressure at which leakage occurs. In the Commission's eyes, the capacity is 2.5 to 3.0 times the design pressure. Ucciferro reiterated this point.

It was mentioned that the small-scale models do not have built-in leak paths (i.e., no gaskets or seals in the models themselves). The large-scale steel model does have gaskets but they do not replicate real gaskets and there is a difficulty in extrapolating (and interpreting) results.

Denning and Cybulskis stated that from a risk viewpoint, leakage on the order of 10% volume per day or greater is of concern and should be considered failure (not leakage which exceeds the Tech Specs).

Burns stated that regarding isolation and penetrations, the NRC has the following activities underway. There is a new program (funding to begin this FY) on equipment qualification which will examine isolation values. Another funded program is examining electrical penetrations, and at the moment, NRC is funding four small efforts at National Labs to ascertain what work should be done on penetrations. In FY83, NRC will fund a

program on penetrations and this program will work closely with the Sandia containment program. (Note that Sandia had originally proposed to do separate effects on penetrations, but this work was not funded, due to budget restrictions).

Leakage and leak rate was discussed several times. For the small-scale steel models, if the failure is not catastrophic, leak rate will be measured as well as can be done without significantly delaying the tests or increasing the cost. For the large scale steel model, both leak rate measurements and measurements of the deformation at the penetrations will be taken. Information regarding the order of magnitude of leak rate will be obtained.

In summary, the consensus of the group was:

1. The steel testing portion of the program is to remain the same, except that one small-scale model of each configuration (clean, ring stiffeners, penetrations) is to be tested. At the completion of these tests, the Peer Review Group will comment on future direction for the small-scale steel models.

2. Innovative steps should be taken in regard to the concrete models.

3. Although penetrations are being tested in the Sandia program, and leakage measurements will be made, the basic thrust of the program is structural. Separate programs will handle questions dealing with electrical penetrations and gaskets and seals.

2. Status of the Program

A brief report on the status of the small-scale models was given. The initial model (designated as Model 0) has been fabricated and helium pressure tested for leaks (1 psig). This model will be used to checkout the experimental set-up. The next model will be delivered shortly. All 6 models are being made as clean shells and will be modified (i.e., the addition of ring stiffeners or penetrations) as needed. Approximately 2/3 to 3/4 of the money allocated for design and fabrication of the small-scale steel models has been spent. To perform six tests will cost $150 - 175 K.

3. Small-Scale Steel Model

It was agreed that the plan for the small-scale steel models would be to test one clean shell, one shell with ring stiffeners and one model with penetrations. The Peer Review Group would attend the third test and at that time, a decision would be made whether any additional small-scale models would be tested and, if so, which configurations.

4. Experiment Plan for the Small-Scale Steel Models

Woodfin distributed a copy of the experimental plan and briefly described the contents.

5. Large-Scale Steel Model

The criteria for this model (approximately 1/10 size) was discussed. Attached to the minutes is the letter from A. W. Dennis, dated May 3, 1982, to the Peer Review Group. The purpose of this model is to determine the effects of actual construction practices on the integrity of steel containments. Since the meeting, the purpose of the test has been modified. The objective of testing the large scale steel model is to: 1) gain additional post-yield information with particular attention placed on the penetration deformation, and 2) obtain information on the amount of deformation necessary to permit leakage.

Comments About The Model

Roger Reedy (by mail and phone) has indicated his concern with the uniform thickness for the cylinder and domes; according to the code, the elliptical base section will control the design pressure.

Dennis - reason for elliptical base, and the same thickness for the dome and cylinder was cost (i.e., the 3/8" thickness dome is considerably less expensive to fabricate than a 3/16" thickness.) The design for the model would be done this FY while fabrication will occur next FY.

Hadjian - raised the issue of why isn't the polar crane included in the model. (They are present in the MK-III and full-steel containments but not in the ice-condensers). After some discussion, it was concluded that it was not necessary to include it in the model.

Stevenson - felt that Sandia is modeling an obsolete containment and it would seem more rational to combine a steel and concrete model; similar to MK-III containment with concrete half way up the wall. However, this will effect the schedule. He also stated the leakage requirement is too tight.

Dennis - pointed out the reasons for the model (see attached letter).

Ahl, Stevenson, Ucciferro - discussed the issue of whether an 'N' stamp should be obtained. There is a difference between building to the "code" and having all the necessary QA/QC to obtain hydro-test, directions from tolerances, pressure relief system, etc.

ACTION ITEM

Dennis will collect nts from entire Peer Review Group and communicate with gr conference calls and mail to resolve the issues.

6. Reinforced Concre

After some disc as agreed that the Peer Review Group, will mail to rs to the following questions.

a) What kind and experimental activities should be n regard to reinforced concrete containm

b) Where shou phasis be?

c) What course tion would you recommend to conform with the advic of Siess, White and Sozen to take the biggest step as fast as reasonably possible.

Included will be one paragraph stating the objective(s) of the model(s).

When this is accomplished, Sandia will send a strawman proposal to the Peer Review Group for their consideration.

ACTION ITEM

Von Riesemann will send a letter to the Peer Review to insure that all members have a copy of the same questions.

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Department of Energetic Systems
October 19, 1982

Dr. Walter A. von Riesemann
Sandia National Laboratories
Albuquerque, NM 87185

Dear Walt:

I'm sorry to be so late in responding to your July 15 request for comments on the program for concrete containment structure models. Part of the delay was caused by my desire to reread and study the initial program plan (on which you recall we helped by reviewing scale modeling and construction options for concrete models at various scales), and by studying the latest plan involving construction and test of six 1/10-scale reinforced concrete models. But, I also delayed because I do not understand why Siess, White & Sozen feel that the present plan is not an attempt "to take the biggest step as fast as is reasonably possible."

In answer to the question "Where should the emphasis be?", my response is:

1) Development of analytic numerical techniques for prediction of elastic-plastic deformations, concrete cracking, etc., for typical reinforced concrete containment shells.

2) Validation (or lack thereof) of analytic/numerical techniques by careful, model-scale testing of prototypical RC shells.

3) Determination of most important failure modes, i.e., catastrophic failure versus leaking beyond some acceptable rate.

4) Role of inner steel membrane in attenuating leakage for permanently-deformed concrete shells.

(Role of penetrations is implied in all of these items.)

In answer to the question, "What kind of analytical and experimental activities should be conducted in regard to reinforced concrete containments," my response is:

1) Stick with the general aspects of the current plan, i.e., develop or apply finite-element codes for prediction of deformation and failure of reinforced concrete shells, with penetrations, etc., under static and then dynamic internal loads, and compare to test results on a series of sub-scale models. The planned 1/10-scale seems to me to be a good compromise between cost of model construction and one's ability to replicate or nearly replicate full-scale construction details.

2) If serious leaking before catastrophic failure is the failure model, be sure to investigate effect of inner steel membrane on such leaking.

3) Instrument model for internal pressure (including leak rate, if possible), deflections, and strains (including perhaps strains in rebars).

4) Run static pressure tests first.

5) Follow by dynamic pressure tests.

In regard to the last item above we (SwRI) can give considerable advice and help on development of a dynamic pressure source, because we have several recent and ongoing programs on measurements of deflagrations and detonations of confined gas mixtures. We can also help in planning dynamic pressure instrumentation, if this help is needed. Our experience in building and impact testing of small model reinforced concrete panels may be of some help, but Dick White's experience in constructing and testing small models of more complex reinforced concrete structures should be much more useful.

My statements on the objectives of the program for reinforced concrete containments are essentially my responses to the question on emphasis.

Finally, the course of action I would recommend to support taking the biggest step as fast as possible is to continue what I perceive to be the present plan. I see only minimal value in planning a single quite large scale test of a complex shell structure with many penetrations, stiffeners, etc, and comparing test results with finite-element programs which haven't been validated by comparisons on simpler concrete structures. Remember that you are hoping to validate prediction methods for plastic deformations/cracking, which don't now exist. If you don't get good comparisons from the results of the single test, you will never be sure whether the code isn't good, or whether local imperfections in the structure cause the differences. Furthermore, if determination of leak rate for a cracked structure is an objective, I would place very little value on the results of a single test. To reiterate, I recommend continuation of the present plan.

Sincerely,

W. E. Baker

W. E. Baker
Institute Scientist

WEB:lr
cc: J. Wilbeck, SwRI