Sandia National Laboratories

Albuquerque, New Mexico 87185

date: May 3, 1982

to: Distribution

A. W. Dennis

from: A. W. Dennis, 4442

subject: Steel Reactor Containment Model -- Criteria for Design, Fabrication and Erection

I am submitting the subject criteria to you for peer review. It is our intention to use this criteria as the basis for design, fabrication and erection of the large steel containment model. This model will be utilized to demonstrate the validity of the results of the small scale steel model experiments and to investigate the potential degradation in internal pressure capacity due tc conventional construction methods and major penetrations.

Please review the attached criteria and submit your written comments by June 1, 1982. The comments will be distributed to all reviewers at the containment workshop in Washington on June 7 and discussed at an Advisory Panel meeting after the close of the workshop. This Advisory Panel meeting is tentatively planned for the afternoon of June 9; if it does not materialize, I will mail copies of all comments and our proposed actions to the reviewers following the workshop.

The model will be prototypical of steel containments (ice-condenser, Mark III, and freestanding) and will demonstrate the essential structural performance of these steel containment, but not necessarily replicate this performance when subjected to internal static pressure.

The proposed model differs significantly from existing containments in three respects.

1. The ratio of wall thickness to containment diameter.

   This ratio is normally at least 840:1, but in the proposed model, a ratio of 352:1 will be used. The principal reason for using the thicker wall in the model (0.375" thick vs. a maximum replica thickness of 0.157") is to allow better

8

replication of welded joints. Secondary reasons are: (1) fabrication cost are reduced because the model can be fabricated in the contractors plant and shipped by rail to Albuquerque, and (2) the minimum thickness of SA 516 grade 70 steel commercial available is 0.1875"; this thickness would translate into a 1/8 scale replica model (for a ratio of 840:1) which in turn would require field erection at a substantially higher price.

2. The design pressure for the model.

The model design pressure will be substantially higher than that of the prototype containments, because the maximum allowable ASME Code pressure will be used. This maximum allowable pressure will be based on the 352:1 diameter to wall thickness ratio rather than the 840:1 ratio of the prototype containments. The principal effect of using this higher pressure will be displayed in the design of penetrations which will also have a substantially higher design pressure than prototype penetrations.

3. The ring stiffner spacing.

The ring stiffners on the model will be placed further apart than they would be if prototype stiffener spacing were replicated. This will allow observation of the effect of the stiffeners on large displacements without effecting the maximum elastic hoop stress response of the shell. If the stiffeners were placed at a replica spacing, they would significantly increase the internal pressure load required to cause hoop stress yielding of the shell.

At the present time, we are soliciting proposals for the design, fabrication and erection of a prototypical steel containment structure. This review is being carried out in parallel with the contractor's preparation of technical proposals and quotations to expedite contract placement. Any criteria changes which result from the review will be incorporated in the contract for design, fabrication and erection of the model. We are planning on awarding a "cost plus fixed fee" contract; thus, a general rather than specific criteria is being used at this time.

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STEEL REACTOR CONTAINMENT MODEL

CRITERIA FOR DESIGN, FABRICATION, AND ERECTION

Introduction

Sandia National Laboratories is currently conducting a research program for the Mechanical/Structural Engineering Branch of the Division of Engineering Technology, Office of Nuclear Regulatory Research, U. S. Nuclear Regulatory Commission. This research program is identified as the Structural Safety Margins for Containments (SSMOC) program and has as its overall objectives:

1. the experimental generation of a data base to assess the methods currently used for predictions of the behavior of light water reactor (LWR) containment structures under severe environments beyond present design requirements,
2. the assessment of selected predictive numerical methods, and
3. the improvement of predictive numerical methods as necessary.

The Steel Reactor Containment Model will be employed in an experimental investigation of post-yield-range behavior of steel LWR containments when subjected to internal pressure. The model will be loaded in such a manner that all design and analysis may be performed assuming an internal static pressure. While the model may experience several loading cycles prior to the post-yield experiment, none of these cycles will be of sufficient magnitude to create a general yield condition in the model.

During the post-yield experiment, the model pressurization will continue until rupture occurs or until the model's leak rate exceeds the capacity of the pressure supply system.

Scope of Work

The contractor shall, as directed by a Sandia Laboratories representative:

(1) design the model in accordance with the specification cited in this criteria and prepare a detailed estimate of costs for fabrication and erection,

(2) design a support structure for the model and prepare a detailed estimate of costs for fabrication and erection,

(3) prepare an information package for use in the peer review of the model and support structure designs,

(4) incorporate peer review comments in the designs,

(5) prepare the necessary drawing and specifications for fabrication of the model,

(6) prepare necessary drawings and specifications for fabrication and erection of the model support structure by others,

(7) fabricate the model,

(8) provide for transportation of the model to the experiment site located on Kirtland Air Force Base, Albuquerque, New Mexico,

(9) erect the model on the support structure, and

(10) repair any damage which the model suffered during transportation and erection.

Sandia Laboratories will procure the model support structure and other required site work under a separate contract.

Quality Control

Quality Control is an important aspect of this program and will be maintained continuously throughout the program. The contractor must maintain quality control records on the design and fabrication of the model as specified in the Code Requirements Section of this criteria.

Model Description

The model shall be designed and fabricated such that, it is representative of the freestanding containment structures utilized by plants such as Davis Besse, Kewannee, Prairie Island and St. Lucie. These plants are characterized by steel containment structures which have a hemispherical dome, vertical cylinder body, and an ellispodial base.

The model must be transportable by rail from the fabricator's plant to Sandia National Laboratories without special permits or handling. This effectively limits the shipment width to 12 feet.

The following dimensions are provided to establish a basis for estimating the costs of model design and fabrication and are subject to revision during the model design process.

Basic Model Dimensions

Vertical Cylinder O.D.	11' - 0"
Overall Model Height	21' - 6"
Hemispherical Dome O.D. ..	11' - 0"
2:1 Elliposodial Base Major Diameter	11' - 0"

3/8" x 5-1/2" Stiffening Rings @ 2' - 0" O.C.

Nominal Wall Thickness (Dome, Cylinder, and Base)	3/8"

The model shall be all welded construction and fabricated from SA-516 grade 70 steel.

The model will incorporate a number of special features which are representative of features found on the prototypes. These features shall be located in relatively the same positions that they occupy in the prototype structrures.

The features are:

1. an equipment hatch penetration (25" O.D.) with a removeable cover,
2. two personnel lock penetrations (12" O.D.) with fixed covers, and
3. two double thickness wall plates (3/4" thick) which simulate reinforced areas for multiple pipe and electrical penetrations. These wall plates will contain the pass throughs for pressure piping and instrumentation to be specified by Sandia Laboratories representative

Additionally, a 30" diameter manway shall be installed in the elliposodial base section to provide personnel access to the interior of the model.

Operating Temperature

The model wall temperature will be maintained at a constant value, at least 10°F above the highest predicted daily temperature for the duration of the experimental loading. Depending on the time-of-year, the wall temperature of the model, during the experiment, will be maintained at a constant value between 40°F and 135°F.

The maximum temperature variations for the model wall in the Albuquerque, NM area will be -40°F to 200°F depending upon time of year. The model will not be pressurized, except during an experiment.

Code Requirements

The model shall be designed and fabricated in accordance with the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section III, Division 1, Subsection NE as a Class MC component. All applicable rules established in Subsection NE for materials, design, fabrication, examination, inspection, testing, and preparation of reports shall be followed and the finished model shall be suitable for registration as an "N Stamp" vessel.

The support structure shall conform to the requirements of the Uniform Building Code and OSHA.

Design Pressure

The design pressure for the model shall be determined by computing the maximum allowable pressure for the basic vessel (dome, cylinder, and base) in accordance with the rules in Article NE-300 of the ASME Code. This computed maximum allowable pressure will be used as the design pressure for basic vessel and the special features.

Leak Rate

At design pressure, the model shall be designed to have a leak rate no greater than 0.1% of its contained mass per day. The actual leak rate shall be determined by tests to be specified by the Sandia Laboratories representative.

Design Effort

It is estimated that the design effort will require approximately 4 man months. Current program planning calls for the model design, peer review, incorporation of peer comments, and preparation of model drawing to be completed by September 30, 1982. The support structure design must be completed by August 31, 1982 to allow placement of a separate contract for its construction. Current planning calls for work to begin on the support structure during October 1982.

Fabrication Effort

Model fabrication is currently expected to begin in November, 1982 and to be completed by March 1983. Model fabrication will be initiated upon receipt of FY83 funds for this purpose by Sandia Laboratories. Site work will be completed during the same time frame.

Shipment of Model

The shipment of the model shall be by truck or rail from the fabricator's plant. The model's expected shipping date is during the winter or early spring of 1983; hence, the model must be packaged in such a manner that transportation loads coupled with low temperatures will not damage the model.

Erection of the Model

The contractor shall be responsible for the erection of the model at Sandia Laboratories experimental site located on Kirtland Air Force Base south-east of the city of Albuquerque, New Mexico. The site is located in the foothills of the Manzano Mountains and is accessible by road. The last 2 miles of this access is an unimproved dirt road.

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Department of Energetic Systems

May 26, 1982

Mr. A. W. Dennis, 4442
Sandia National Laboratories
Albuquerque, New Mexico 87185

Dear Al:

I have reviewed the criteria for design, fabrication and erection of the tenth-scale steel reactor containment model, and have the following comments:

(1) The deviations from exact replication of a 1/32-scale model are acceptable, given the thrust of the experiments as testing to validate analysis methods. Even though the model will be about twice the thickness of a replica, it is still a very thin ring-stiffened shell, so basic failure modes should be the same.

(2) The criteria are explicit and complete enough to allow potential designers and fabricators to submit realistic proposals. I take it that either separate contracts may result for design and for fabrication and erection or a single contract may cover both design and fabrication.

(3) For later correlation with analysis, you should know the detailed constitutive properties of the shell material under both static and dynamic conditions, up to rupture. Either as a part of the fabrication contract, or separately, specimens of the shell material should be tested to obtain uniaxial and biaxial stress-strain tensile data up to failure.

(4) Is the base design and support intended to be similar in the tenth-scale and 1/32-scale models? I recall considerable discussion on this point in previous committee meetings.

(5) Perhaps the potential designer of the model should have the benefit of committee discussions on hatch and closure designs to maintain leak tightness. Otherwise, he may spend an inordinate amount of design effort in an attempt to satisfy this item in the criteria.

As you probably recall, I have a conflict which prevents my attending the Workshop on June 7-9, and the Advisory Panel meeting on June 9. Dr. James Wilbeck will attend in my place.

Sincerely,

W. E. Baker
Institute Scientist

WEB:sc

cc: J. S. Wilbeck

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May 26, 1982

Mr. A. W. Dennis
SANDIA NATIONAL LABORATORIES
Albuquerque, New Mexico 87185

Subject: Steel Reactor Containment Model
Criteria for Design, Fabrication and Erection

Dear Mr. Dennis:

I have reviewed the criteria sent to me with your letter of May 3, 1982. My first comment is that I feel a sketch of the containment model should be attached to the criteria document. Although I can visualize what you intend the model to look like after reading the complete specification, it would have been easier if I had had a sketch. My concern is that the model fabricators bidding on the model may not understand some of the descriptions in the criteria document because of not having a sketch of the model.

My detailed comments on the criteria document are as follows:

1. I see no reason to procure the model support structure under a separate contract from the containment model. Because the containment model will have an ellipsoidal head, it will be necessary to fabricate at least a portion of the vessel in the horizontal position. This means that some of the welding positions used in fabricating the model will be different from those used in the field on an actual containment. I would prefer that welding positions used on the model correspond to those used for a field-erected containment. If corresponding welding positions were used, it would be logical for the shop fabricator of the model to support it in the upright position. The structure used to do this could then be used for testing.

2. It is obvious from the criteria document that the bottom head, which is ellipsoidal, will not be embedded in concrete during the test. Free standing containments with ellipsoidal heads are

10

always embedded in concrete. In addition, when using the design rules of Section III, Subsection NE of the ASME Code, ellipsoidal heads are the governing item to determine the maximum allowable pressure. This is because Section III requires the use of stress intensities for the design of elipsoidal heads under internal pressure. In other words, the item of least concern is the design of the model.

In addition, the model's cylindrical shell will not be controlling and the effective stiffness on the shell will be less meaningful when making comparisons to actual containments. It seems to me that the cylindrical shell with its openings should be the critical portion of the containment, but the model will be governed by factors not related to that. A solution to this problem would be to make the bottom head thicker than 3/8 inch thick. Also the effect of the internal and external concrete around the ellipsoidal head of the freestanding containments will not be demonstrated by the model test. Is this a concern?

3. Quality Control is mentioned in the criteria document as an important aspect of the program. I feel that although quality control is extremely important, the paragraph really discusses quality assurance.

4. Since the model will have a hemispherical top head twice as thick as required by the ASME Code, it will not be a governing factor in the failure of the containment vessel. The model head will be twice as thick as any containment it is intended to model. Because the design factor (factor of safety) of hemispherical heads (about 2.3) under external pressure is less than for cylindrical shells (about 3.0) under the rules of the ASME Code, I feel it is wrong for the model to have a head twice as thick as required by the Code. Although the criteria document addresses internal pressure only, there may be some desire to test the effect of external pressures also.

5. As an idea to save on costs, I suggest that the 30 inch diameter manway in the bottom head be eliminated because an equipment hatch penetration with a removable cover is already provided in the shell. The differences in diameters for these two openings does not appear to be that significant as far as personnel access is concerned.

6. One of my most important comments is that I feel that all the requirements of the ASME Section III for Subsection NE must be met in order to procure a realistic model. I have seen many cases where equipment is fabricated to all the requirements of the ASME Code "except...", where the result has been that many essential Code requirements are not met. It is extremely important that the fabricator of the model have a Quality Assurance Program that meets the requirements of Section III and which is accepted by an ASME Survey Team. It is also important that the fabricator of the model have a contract with an Authorized Inspection Agency and that the containment model be inspected to the requirements of Subsection NE by an Authorized Nuclear Inspector.

   It is also important that qualified welders and qualified welding procedures be used. Fabricators who have not been authorized by ASME may not be able to adequately meet these requirements. In addition, I feel that an "N Stamp" should be furnished for the vessel.

7. The support structure for the model should conform to the requirements of Subsection NF for Component Supports. My concern about this is that the support may be welded to the containment vessel and if the requirements of Subsection NF were not met the structure might not be compatible for welding to the containment model.

8. Under "Design Pressure" in the criteria document, the proper article is NE-3000 of the ASME Code. In addition, the computed maximum allowable pressure will be governed by the ellipsoidal head rather than the cylindrical shell, which I believe is your intent. Also the top head will be twice as thick as required by the ASME Code.

9. I do not understand how you will design the model to have a leak rate in accordance with the criteria document. The vessel will either be fabricated to the requirements of the Code, or it will not. But the leak rate will not be influenced by the fabrication techniques used. The leak rate is something that should be determined after the model has been procured, and should not be part of the purchase specification. If any leaks do exist in the model, they will be around seals or gaskets and not through welded joints. Therefore, the model fabricator will not have control over the model leak rate established by the criteria document. In addition, the leak rate proficiency of the model will have no substantive effect on the tests that are to be performed. Radiography of all welds will take care of the leak rate requirement. If there is concern about leakage through the welds then a hallide leak detector test or an equivalent could be used to locate problem areas. This is a test which can be performed by the model fabricator.

10. There is not enough information given in the criteria document to design the support structure. If the only load to be considered is dead load than the design is extremely simple and could be done in a few days by a competent engineer.

If you have any comments, or would like to discuss any of this please feel free to call me.

Very truly yours,

Roger F. Reedy

Roger F. Reedy, P.E.
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May 27, 1982

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Mr. A. W. Dennis
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Steel Reactor Containment Model
Criteria for Design, Fabrication and Erection

Dear Mr. Dennis:

In accordance with your request, I have reviewed the subject criteria and have the following comments, all related to the requirement that the finished model "shall be suitable for registration as an N Stamp Vessel". I believe that this requirement is too restrictive in that it has the potential to cause unnecessarily high costs and schedule delays with little if any increase in the quality of the model.

Your goal is to design, fabricate and erect a quality model such that capability is not underpredicted due to model defects. You should be able to accomplish this goal without the cumbersome paperwork and quality assurance requirements associated with N Stamp vessels. You should require, as a minimum, certified mill test reports, supplier qualification, welder qualification, radiographic weld inspection by qualified inspectors, design specification, stress report, etc.

For an N Stamp vessel some of the items you will be required to provide are given below.

- Implementation of a Quality Assurance Program - A detailed Quality Assurance Manual will be needed. As always provisions contained in these manuals will be the source of much interpretation and the related time consuming discussions.

  Evidence of implementation of the manual must be documented. Existing Quality Assurance Manuals in most organizations relate to full nuclear projects. Something less would be satisfactory for your purpose but would have to be written specifically for your needs.

- Requirements for training programs will need to be prepared. You may be required to have training sessions for specific aspects of fabrication, etc.

- Design Control Requirements must be implemented. Management level reviews may be required.

- Document Control Requirements need to be established.

(11)

- A Vendor Surveillance Program must be established. Process control sheets, etc. must be developed. For example, welding must be documented at each step. Pre-selected check points must be established for quality assurance sign off.

- Pressure testing must be performed. The source of any leakage must be repaired. The vessel would then have to be retested.

- The vessel will need to conform to specified erection tolerances.

- Once a "design pressure" has been established, you may be required to protect against overpressure by providing relief valves, etc. in the model as required by NE7000.

You should note that there are no provisions for deviations from ASME Section III Division 1. You must meet all requirements for an N Stamp. If you fail to meet a requirement such as specific tolerance and demonstrate, with an engineering evaluation, that the vessel is satisfactory, there is no ASME mechanism for acceptance.

You may want to commit to the technical requirements of the Materials, Design, Fabrication and Installation and Examination sections of Division 1. You may elect not to conform to the extensive Quality Assurance requirements set forth in NCA - General Requirements. Also, you should add the flexibility for engineer sign off where you do not meet Code, but can demonstrate acceptibility.

In conclusion I see no reason to commit to an N Stamp for the steel containment models. Since it seems totally impractical to specify this requirement for the concrete models you will test, there will be no loss of consistency by deleting it here.

Very truly yours,

J. J. Ucciferro

J. J. Ucciferro
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May 28, 1982

SANDIA NATIONAL LABORATORIES
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Attn: Mr. A. W. Dennis

Subj: Steel Reactor Containment
Criteria for Design, Fabrication and Erection

Gentlemen:

I have reviewed your write-up covering the criteria for design, fabrication and erection of the steel reactor containment model as requested in your May 3, 1982 letter. I have the following comments:

1) Ratio of Wall Thickness to Containment Diameter

a) Your write-up acknowledges that the D/t ratio for the referenced vessels is at least 840:1 and that the proposed model is based on 352:1. You further state that the use of .1875 thick plate and a 840:1 ratio would result in a 1/8 scale replica which would exceed the shipping clearances. I feel that we should consider the possibility of using the 1/10 scale diameter and height, i.e., the 11'-0" O.D. by 21'-6" vessel and a .25 or .1875 shell thickness. The D/t ratios for these alternates are 526 and 703, respectively. Although these ratios would not match the D/t of 840, they would provide a more realistic approximation.

It appears one of the major factors in determining the thickness is the ability of the vessel fabricator to produce a formed head which is free of local distortions and gross out-of-round deviations.

The other factor is the ability to replicate the weld joints. It may be possible for a fabricator to form the heads and replicate the joints for thicknesses of .25" and .1875". This possibility should be pursued.

b) The write-up suggests that there is a 12' diameter shipping limitation. Our Operations Department has questioned this limitation and feel that it may be unduly restrictive. I suggest that this issue be reconsidered. Also, the economics of a field erected test vessel should be considered.

(12)

2) The Design Pressure for the Model

a) The write-up does not clearly state whether the test is to be a pneumatic or hydrostatic test. Considering that the vessel is to be tested to failure, I recommend the use of a hydrostatic pressure test. Naturally, this will have a significant effect on the design of the test stand. I recommend that the write-up clearly state the type of test intended.

b) The write-up should indicate the type of test (hydrostatic or pneumatic) that must be used during the leak rate test. I recommend that the leak rate test pressure and the applicable standard ANSI/ANS-56.8-1981 be referenced in the write-up.

3) The Ring Stiffener Spacing - Base Stiffener at Bottom Head

The reference vessels have 2:1 ellipsoidal bottom heads which are embedded in concrete. This embedment zone is composed of internal and external concrete which provides complete restraint of the bottom head in this area. I suggest that some type of heavy ring stiffener be added at the bottom tangent line to simulate the stiffness of the concrete. The test stand could be designed to incorporate this stiffness if necessary.

In addition, it may be necessary to increase the shell thickness in the knuckle region in order to prevent buckling due to circumferential compression. Naturally, placing concrete in the bottom head would also eliminate this potential problem.

Please consider these comments in your assessment of the program. I intend to attend the June 9, 1982 meeting and would like to discuss these comments at that time.

Sincerely,

Thomas J. Ahl

Thomas J. Ahl
Design Engineer Supervisor
Special Structures Design

TJA/lp

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June 1, 1982

Mr. A. W. Dennis
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Albuquerque, New Mexico 87185

Dear Mr. Dennis:

Rich Denning has asked me to comment on the "Steel Reactor Containment Model - Criteria for Design, Fabrication, and Erection" that you had sent to him for his review. My observations are as follows:

1. While there are obvious incentives for shop fabrication of the model vessel, the fabrication processes should replicate as closely as is reasonable the field fabrication techniques utilized for the prototype containments. It is possible that shop fabrication will permit the attainment of a higher level of quality than is typically obtained in the field; if this were the case, the results of the testing could be misleading.

2. The specifications for the steel plate material to be used differ somewhat with the thickness of the plate. The plate thickness in the model will be different from those utilized in prototype containments; thus, steps should be taken to ensure that the model replicate prototype practice.

3. It is apparently intended to test the model vessel at the prevailing ambient temperatures. The accident environments of interest will typically involve elevated temperatures, in some cases only slightly above design levels and in others significantly beyond. It would appear that some further thought should be given to the allowable operating (testing) temperature range. While not necessarily advocating testing at high temperature, I would be concerned with tests at the lower range of temperatures (40 F) suggested.

4. The criteria for the design of the support structure for the model vessel are not detailed. At large deformations a model that is simply supported could behave differently from one imbedded in concrete, for example. Further consideration in this area may be appropriate and reference should be made to prototypical practice. Also in line with the foregoing, both flat as well as ellipsoidal bottoms have been used for steel containments. Is one more representative than the other?

5. The plan calls for the use of ring stiffeners, but at a spacing which will not unduly influence the response of the shell. While I am aware that both vertical and horizontal siffeners have been used on some containments, it is not clear to me that this is a typical practice.

I hope that the above comments will be of benefit; if you should have any questions please feel free to contact me at (614)424-7509.

Sincerely,

Peter Cybulskis

Peter Cybulskis

PC/llj

cc: R. S. Denning, BCL
W. A. von Riesmann, Sandia

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July 13, 1982

Mr. A. W. Dennis
Systems Safety Technology Division
9442
SANDIA NATIONAL LABORATORIES
Albuquerque, New Mexico 87185

Subject: Peer Review Comment on Large Steel Model

Dear Mr. Dennis:

I have reviewed the peer comments and my further observations are as follows:

I. Comments by Mr. Peter Cybulskis of Battelle

1. I believe the difference in welding thicknesses of 3/8 inch vs. 1 1/2 inch will have a greater impact on the final configuration of the model than the difference between shop and field fabrication. In actual fabrication, double butt welds were used on the shell courses, whereas on the material for the model, single butt welds will probably be used, which will have an effect of local distortion.

2. For the type of steel used in the model, I do not believe there will be any difference in the mill melting and rolling practices between 3/8 inch and the 1-1/2 inch plate. I would be more concerned if steel thinner than 3/8 inch were used. There may be some differences in thickness in the model material because of roll cambers at the mills, but this should not be too significant.

3. For the steel being used, I am not concerned about 40°F temperatures. SA-516, Grade 70 material has good impact properties at 0°F.

4. I certainly agree that a simply supported pressure vessel with a hemispherical head will act differently than a vessel which has a concrete flat bottom, or one which has an ellipsoidal head buried in concrete.

5. It is not common practice to use vertical stiffeners on containment vessels designed to ASME Code requirements. In the Code, design credit is only given for circumferential stiffeners.

II. Comments by Mr. W. E. Baker of Southwest Research Institute

1. No comment.

2. No comment.

3. I am not convinced that biaxial stress-strain tensile data should be obtained on the thin steel as it would be different from the steel 1-1/2 inches thick. Also no biaxial stress-strain tensile data was ever obtained for containment vessels that have been built in the past.

4. No comment.

5. I do not see any real problem in obtaining hatches and closures adequate to maintain the specified leak tightness.

III. Comments by Mr. J. J. Uciferro of United Engineers & Constructors

1. I feel that the fabricator of the model should be a qualified containment vessel manufacturer with the capability of N-stamping the vessel. However, the model should not be Code stamped. This will eliminate any concern about "cumersome paperwork". Containment vessels are not nuclear reactors and if the fabricator has been qualified by ASME, there will be no QA problem, because the program will already be in existence. Since the vessel is small and simple, the amount of paperwork is, of necessity, almost negligible. For a qualified fabricator there will be no problem with an interpretation of Code requirements. The important thing is to work with a QA system used for containment vessel construction.

   Design control, document control and vendor surveillance will already have been established for a qualified fabricator. Since the vessel is not to be stamped, there is no concern about pressure testing. In addition, the vessel tolerances on a

containment vessel are extremely liberal and for shop fabrication will cause no concern in any way. Also, there is no requirement in the Code for protection against over pressure on a containment vessel and certainly not on a model. Because the main purpose of a containment is to protect against radioactive release, no containment vessels have ever been constructed with pressure release devices

2. For the model you do not want any deviations from Section III design and fabrication requirements. Since the vessel is not stamped, other necessary deviations are not a problem. Meeting all the requirements of the Code is only required when a vessel is to be N-stamped.

IV. Comments by Mr. Thomas J. Ahl of Chicago Bridge & Iron Company

1. I agree.

2. The potential energy for a hydrostatic test is many times less than that of a pneumatic test. I agree with the comment.

3. I agree with the comment. As pointed out in my prevous letter, the bottom head, which ordinarily would be embedded in concrete will determine the allowable pressure of the model.

If there are any further comments or discussions on this, please feel free to call me.

Very truly yours,

Roger F. Reedy, P.E.
R. F. REEDY, INC.

RFR:na

STEVENSON & ASSOCIATES

a structural-mechanical consulting engineering firm

9217 Midwest Avenue • Cleveland, Ohio 44125 • (216) 587-3805 • Telex: 985570

0579A
81C146

11 August 1982

Mr. A. W. Dennis
Sandia National Laboratories
Albuquerque, New Mexico 87185

Dear Mr. Dennis:

Please excuse my tardiness in responding to your letter of 3 May 1982. These comments which I discussed with you in Washington at the Containment meeting are primarily for the record. My specific comments on your Criteria for Design are as follows:

1. How do you intend to reinforce penetrations in the shell - area replacement, and if so, what are the dimensions to be used?

2. What are the dimensions of 3/4" wall plate inserts?

3. The description of "operating temperature" does not adequately define the thermal design requirement on the structure.

4. Under "code requirements" the...design and fabrication" wording should be changed to "constructed" as this is ASME code nomenclature for the entire process - material, design, fabrication, inspection, erection, etc.

5. I strongly recommend that Q.A. program requirements be limited to only those typically associated with conventional pressure vessel and not include 10CFR50 Appendix B or ASME Section III level of Q.A. In my opinion, inclusion of current nuclear Q.A. requirements would greatly inflate costs and would not be representative of the majority of nuclear containment vessels which were designed and fabricated before 10CFR50 Appendix B or current ASME Section III requirements were established.

Sincerely,

John D. Stevenson
President

JDS:clj

(15)

Sandia National Laboratories
Albuquerque, New Mexico 87185

date: February 26, 1981

to: Advisory Group
Safety Margins for Containments

from: Walter A. Von Riesemann
Division 4442
Sandia National Laboratories
Albuquerque, NM 87185

This letter will cover a variety of topics.

1. Enclosed is a list of the potential members of the advisory group. I am enclosing the list even though all of you have not yet formally agreed to be on the panel. Some of you have indicated that there might be some difficulty in serving on the advisory group. I hope you all are able to serve.

2. A draft copy of the program plan will be sent to you by March 9th for your review and comment.

3. A meeting of the group and Jim Costello, NRC, and the involved Sandians is planned for Silver Springs, Maryland on March 27, 1981. Final details will follow. I would appreciate written comments on the plan before we meet.

I will call you next week.

WAVR:ds

(1)

Sandia National Laboratories
Albuquerque, New Mexico 87185

March 10, 1981

Meeting Highlights

Location: Willste Building
7915 Eastern Avenue
Silver Spring, Maryland
Room 130 (badge will be required)

Time/Date: 9:00 a.m. to 5:00 p.m.
Friday, March 27, 1981

Parking: Parking Garage (you'll need quarters)
see map for location

Metro: Service from Washington National Airport and Union Station.
Stop is Silver Spring
and is about a 10 minute walk from the NRC Building.

Contact: Dr. James F. Costello
Room 1036, Willste Building
Telephone: 301/427-4444

Motels: Silver Spring
Holiday Inn, 8777 Georgia Avenue
301/589-0800

Sheraton Inn, 8727 Colesville Road
301/589-5200

Bethesda
Marriott Hotel, 2 Pooks Hill Road
301/897-9400

Holiday Inn, 8120 Wisconsin Avenue
301/652-2000

Chevy Chase
Holiday Inn, 5520 Wisconsin Avenue
301/656-1500

Rockville
Sheraton-Potomac Inn, 3 Research Court
301/840-0200

Ramada Inn, 1251 W. Montgomery Avenue
301/424-4940

(2)

TO BELTWAY
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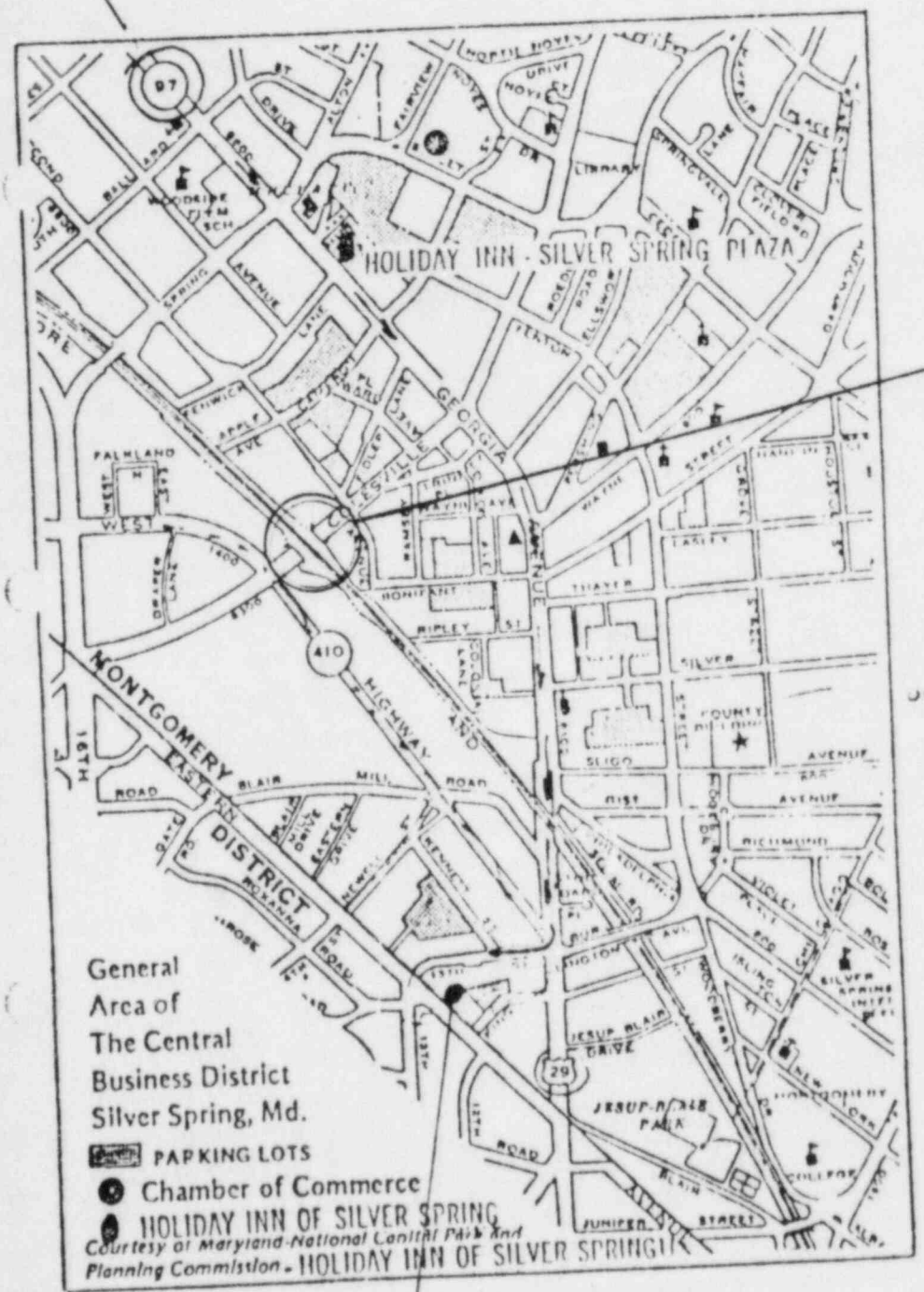

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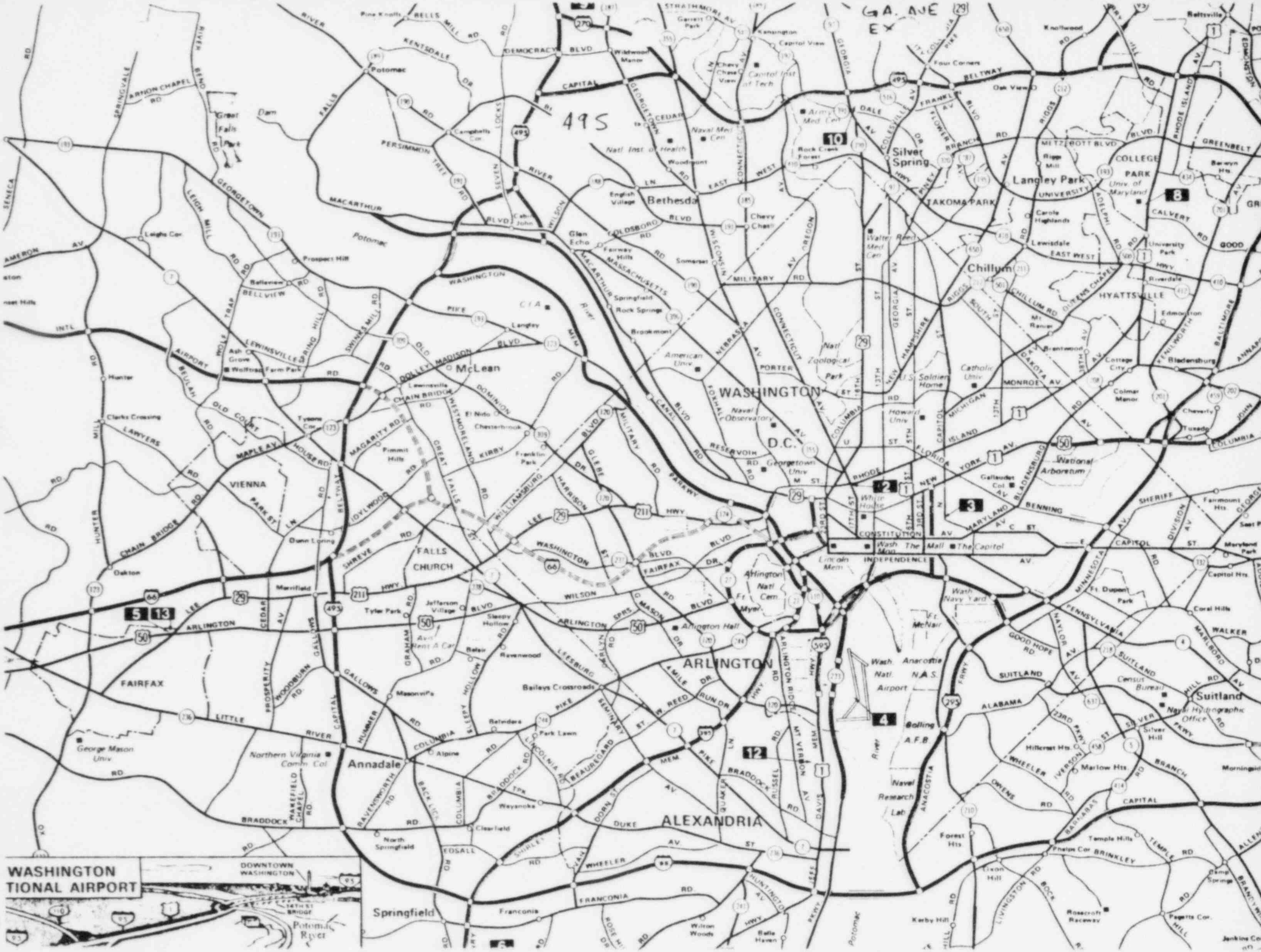

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National Arboretum
Naval Observatory
George Mason Univ
Northern Virginia Comm. Col.
Naval Research Lab
Census Bureau
Univ. of Maryland
CIA
Wash Navy Yard
Ft. McNair
Anacostia N.A.S.
Natl Inst. of Health
Naval Med Cen
CAPITAL BELTWAY
WASHINGTON NATIONAL AIRPORT
DOWNTOWN WASHINGTON
14TH ST BRIDGE
Potomac River

Sandia National Laboratories
Albuquerque, New Mexico 87185

May 21, 1981

To: Advisory Group
Safety Margins for Containments

From: A. W. Dennis

Subject: Meeting of the Safety Margins of Containments Advisory Group at NRC on March 27, 1981

Enclosed is a summary of the March 27, 1981 Advisory Group Meeting.

AWD:ds

Copy to:
USNRC W. F. Anderson
USNRC G. Arndt
USNRC G. Bagchi
USNRC J. Costello
USNRC H. Polk
USNRC L. Shao
CBS K. Moktarian
4442 W. Von Riesemann
4442 T. Blejwas
4442 A. Dennis
4442 R. Woodfin

(3)

Meeting of the Safety Margins of Containments
Advisory Group at NRC on March 27, 1981

The following personnel were present:

Advisory Group Members

Dr. Wilfred Baker, Southwest Research Institute
Professor Mete Sozen, University of Illinois
Dr. Joseph Ucciferro, United Engineers & Constructors
Professor Richard White, Cornell University
Kam Moktarian (representing Tom Ahl), Chicago Bridge & Iron

NRC

William F. Anderson
Goutam Bagchi
James Costello
Gunther Arndt
Harold Polk
Lawrence Shao

Sandia National Labs

Walter A. Von Riesemann
Thomas E. Blejwas
Albert W. Dennis
Ronald L. Woodfin

The follow constraints were placed upon the program by James Costello:

1. Program costs should not exceed two million dollars per year (1981 dollars assumed) and program duration should be adjusted accordingly.

2. Ultimate static presure capacity of MARK III and Ice Condenser containments is to be given first priority. Ultimate static pressure capacity of reinforced concrete and prestressed concrete containments is to be given second priority. Internal explosive loading of the three types of containments should be considered following the determination of static capacities. Seismic ultimate capacity is currently a low priority item and should be considered last.

3. Development of methods for the analytical determination of containment ultimate capacity under static pressure, dynamic pressure, and seismic action is a primary objective of this program.

Advisory Group recommendations can be summarized as follows:

1. Initial emphasis should be placed upon the testing and analysis of structures which are axisymmetric (such as, a ring stiffened steel shell) and structures which possess several axes of symmetry (such as, a ring and rib stiffened shell).

2. The possibility of component testing and analysis for major penetrations (such as, equipment hatches and personnel locks) should be investigated and utilized if feasible.

3. Development of analytical methods should be emphasized and experimentally verified.

4. Section 7 of the program plan document should be revised to meet the NRC funding constraint (if practical) and to include the static pressure program for reinforced concrete and prestressed concrete containments.

5. Section 8 of the program plan document should be revised to show costs and schedules for the revised program presented in Section 7.

6. The free-standing steel is to be examined first, and a generic rather than a specific design should be used.

The advisory panel did not, as a group, reach any conclusion or make any recommendations on the following items:

1. The number and scale of replica models to be tested.

2. Analytical methods which should be employed or excluded, i.e., there is some question as to the use of proprietary computer analysis methods.

Sandia Labs is responsible for the revision of the program plan which will now incorporate (where feasible) the constraints imposed by the NRC and the recommendations of the Advisory Group. This revised program plan will be mailed to the Advisory Group prior to the next meeting.

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: May 27, 1981

to: Containment Advisory Group

Walt.

from: Walter A. Von Riesemann

subject: Chicago Meeting - June 9-10, 1981

We will meet at the offices of Chicago Bridge & Iron Company,

800 Jorie Boulevard
Oak Brook, Illinois 60521
312/654-7365

A map and agenda are enclosed. We are starting the meeting on June 9th at 10:00 a.m. in order to allow some of you to fly into Chicago the morning of the meeting.

We have contacted the

Holiday Inn/Oakbrook Terrace
17 W. 350 22nd Street
(22nd St. (Cermak Rd) off I-5,
W - of I-294 & Rt. 83)
312/833-3600

and they have set aside a block of rooms for Sandia Labs at a rate of $48. There is a limousine service from O'Hare to Oak Brook. Details are enclosed. Either CB&I (call Tom Ahl, 654-7365) or one of us can drive you over to the meeting area.

WAVR:ds

(4)

AGENDA

Advisory Group - Containments

Location - CB&I, 800 Jorie Blvd.
Oak Brook, Illinois
312/654-7365

Tuesday, June 9, 1981

10:00 AM	Overview of the containment program - Costello, Von Riesemann
10:30 AM	Review of comments from last meeting - Von Riesemann
11:30 AM	Lunch at CB&I lunchroom
12:30 PM - 5:00 PM	Presentation of revised program - Von Riesemann, Blejwas, Dennis, Woodfin
	Informal Dinner

Wednesday, June 10, 1981

9:00 AM - 11:30 AM	Resolution of comments
11:30 AM	Lunch at CB&I lunchroom
12:30 PM - 2:00 PM	Approval of Program


PLAINES
DES PLAINES OASIS
ELK GROVE VILLAGE
PARK RIDGE
ROSEMONT
SCHILLER PARK
CHICAGO O'HARE INTERNATIONAL AIRPORT
O'HARE OASIS
BENSENVILLE
FRANKLIN PARK
NORRIDGE
HARWOOD HEIGHTS
RIVER GROVE
ELMWOOD PARK
NORTHLAKE
MELROSE PARK
ELMHURST
OAK PARK
VILLA PARK
BERKELEY
BELLWOOD
MAYWOOD
HILLSIDE
DWIGHT D. EISENHOWER FOREST PARK
BROADVIEW
WESTCHESTER
NORTH RIVERSIDE
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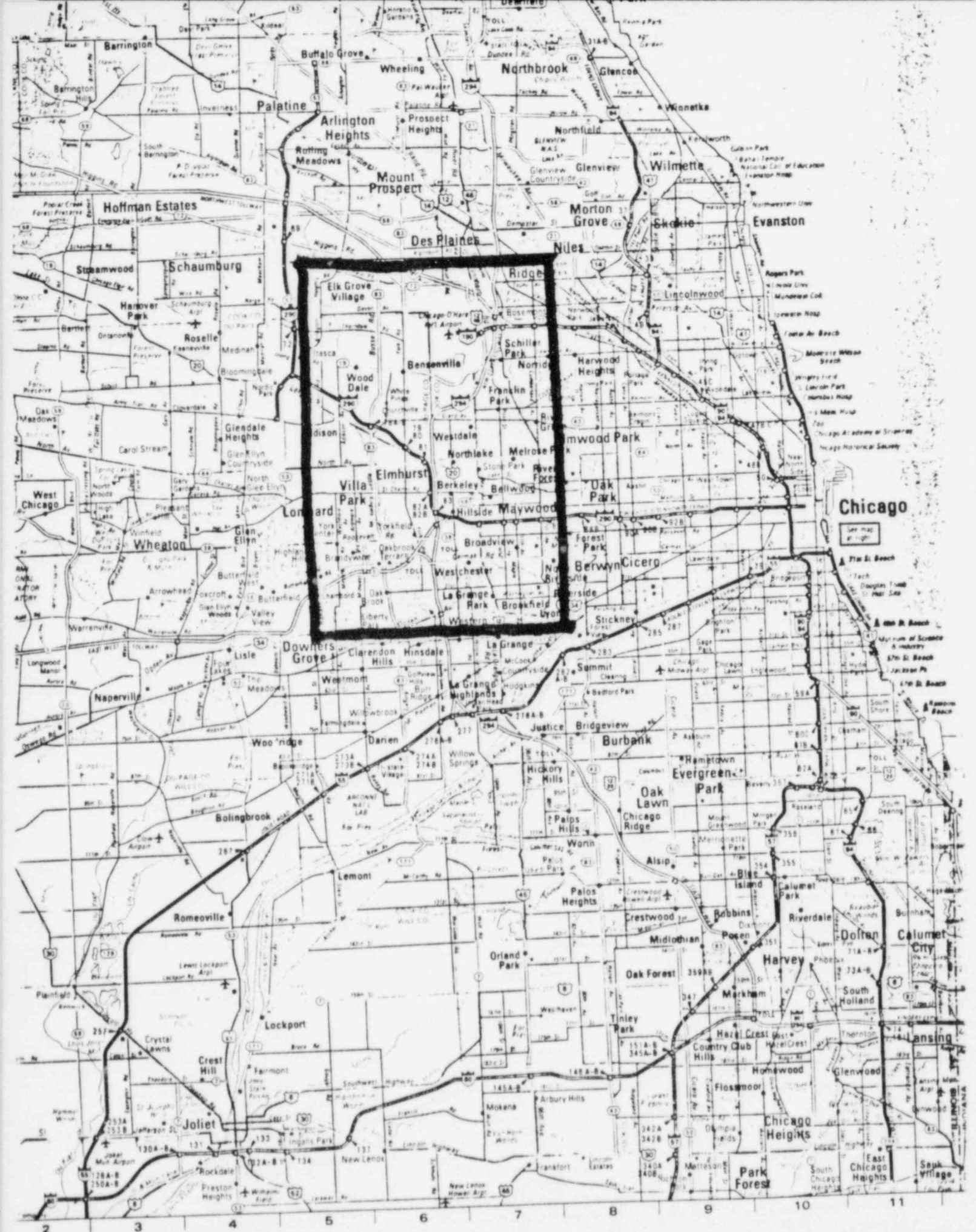
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Elk Grove Village
Lincolnwood
Schiller Park
Bensenville
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Northlake
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Villa Park
Berkeley
Bellwood
Oak Park
Chicago
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Maywood
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Oak Lawn
Bolingbrook
Palos Hills
Chicago Ridge
Worth
Alsip
Lemont
Blue Island
Calumet Park
Palos Heights
Romeoville
Crestwood
Robbins
Riverdale
Midlothian
Posen
Dolton
Calumet City
Orland Park
Harvey
Oak Forest
Plainfield
Markham
South Holland
Tinley Park
Lockport
Hazel Crest
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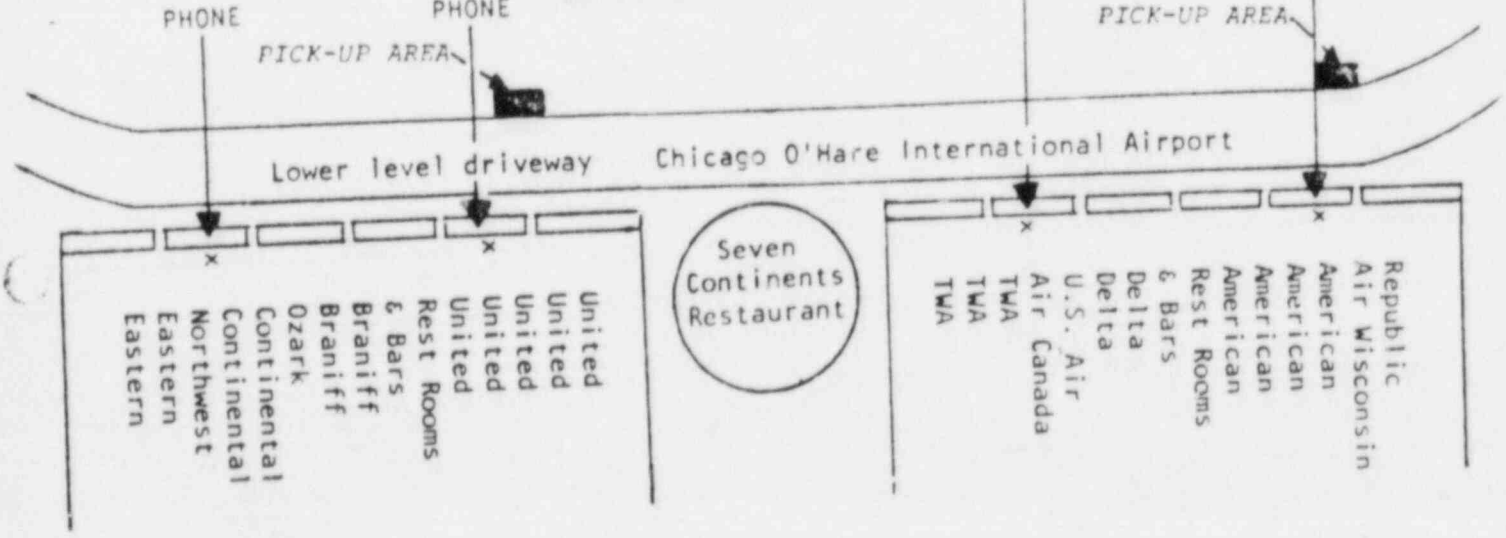

Sandia National Laboratories
Albuquerque, New Mexico 87185

August 20, 1981

To: Advisory Group
Safety Margins of Containments

From: A. W. Dennis
Division 4442

Subject: Summary of the June 9 & 10, 1981 Safety Margins of Containments Advisory Group Meeting

Enclosed is a summary of the Advisory Group discussion held on June 9 & 10, 1981.

AWD:ds

Copy to:
CB&I K. Moktarian
USNRC J. Costello
4442 W. A. Von Riesemann
4442 T. E. Blejwas
4442 R. L. Woodfin
4442 File (1047.011)

(5)

Meeting of the Safety Margin of Containments Advisory Group at the Chicago Bridge and Iron Offices, Oak Brook, Illinois on June 9-10, 1981

The following personnel were present:

Advisory Panel Members

Mr. Thomas Ahl
Dr. Wilfred Baker (June 10)
Dr. Asadour Hadjian (evening of June 9)
Prof. Mete Sozen (June 9)
Dr. John Stevenson
Dr. Joseph Ucciferro
Mr. Kam Moktarian (panel advisor)

NRC

James Costello

Sandia National Laboratories

Walter Von Riesemann
Thomas Blejwas
Albert Dennis
Ronald Woodfin

Tuesday, June 9, 1981

The major activities were:

1. An overview of the current level of technology with respect to the prediction of containment failure as the result of extreme overpressurization loadings which might be imposed upon the structure by Class 9 type reactor accident or seismic loading more severe than the Design Basis Earthquake;

2. A review of comments from the last Advisory Group meeting (N.R.C., Silver Spring, MD., March 27, 1981); and

3. Presentation and discussion of Sandia's revised program plan.

Wednesday, June 10, 1981

The resolution of comments and program approval were the major goals of this session. The Advisory Group was in general satisfied with the revised program plan for hybrid steel (free-standing) containments subjected to internal static pressure loading; however, several questions were raised and discussed during the session. The questions and their resolution are summarized below:

1. Question: Can sufficient detail be included in 1/32 scale models to be useful in the evaluation of containment structures? Specifically, the following comments were raised and discussed: leakage through gaskets and seals would not be addressed at this scale; welding procedures are substantially different and hence weld defects will be different; fabrication of scale model components such as the dome will be substantially different (i.e., a single element metal spinning vs. a multi-element stamped weldment) and small details such as piping penetrations will not be present in the 1/32 model.

Resolution: The 1/32 model Phase I experimental program's principle purpose is to obtain large deflection data on axisymmetric structures which may be employed directly in the preliminary screening of numerical analysis methods. Sandia does not intend this series of experiments to address leakage through gaskets, failures initiated by small structural details, or welding replication.

The proposed 1/32 scale Phase II experiment will address the question of containment degradation due to major penetrations. The Phase III experiments on a "full-up" model will be a replica

model tests of the "prototype" 1/8 scale containment. At this time it may be necessary and/or desirable to employ a larger scale. Details of the Phase III experiments, including model scale, will be discussed at a future Advisory Group meeting after the configuration of the 1/8 scale "prototype" has been determined.

2. Question: Should the largest model under consideration (1/8 scale) be tested first to establish a failure mode of interest? If this were done, then the smaller scale models would be used to investigate this failure mode in greater detail.

Resolution: This approach is not acceptable to the NRC, therefore, the 1/32 scale Phase I and II tests will proceed as planned. Sandia will investigate the desirability of utilizing larger scales for the Phase III experiments.

3. Question: Should an ellipsoidal as well as a hemispherical dome be investigated in the early 1/32 scale experiments?

Resolution: The inclusion of the ellipsoidal dome in the program is an expansion of the experimental matrix which will result in additional program costs and additional program time. The impact on program budget and schedules will be investigated by Sandia. The decision to fund the additional experiments rests with the NRC.

4. Question: Should the crane rail girder which is present in several of the free-standing steel containments be included in the 1/32 scale experiments?

Resolution: The inclusion of the crane rail girder in the program is an expansion of the experimental matrix which will result

in additional program costs and additional program time. The impact on program budget and schedules will be investigated by Sandia. The decision to fund the additional experiments rest with the NRC.

5. Question: What level of quality control will be employed in the program? Specifically, how will quality control with respect to welding methods, ductility and impact resistance be incorporated in the program?

Resolution: Quality assurance and control methods will be developed and employed throughout the program. These methods will follow the guidelines which are normally utilized by NRC and DOE on a research project such as this. Sandia's Light Water Reactor Safety Department has a resident Quality Control Officer who is responsible for the implementation of quality assurance on all such projects within the department.

6. Question: Will bolted joints, which are present at locations other than the base of the containment on some structures, be considered in this program?

Resolution: Bolted joints other than the base connection will not be considered in the model studies. These joints may be considered in separate effects tests if NRC directs that they be included.

7. Question: Should the basic program be directed toward full scale and model experiments on components which have a potentially higher probability of leaking before catastrophic failure of the containment or should it be directed toward models which are more suitable to the prediction of ultimate (catastrophic failure) capacities?

Resolution: Sandia believes that this program should consider prediction of catastropic containment failure as its first priority. The experimental program has been developed on this basis.

8. Question: The concrete base mat is thought to be the weak link in some free-standing steel containments. Should the base mat receive a greater proportion of the experimental consideration?

Resolution: The decision on the base mat question will be deferred until it is determined if this question is plant specific or if it is generic.

The meeting adjourned with the following consensus:

1. Sandia should proceed with the 1/32 scale Phase I and II experimental program as outlined in the revised program plan.

2. Sandia should perform a structural analysis of the proposed 1/32 scale model and present the results at an advisory group meeting. The analysis will be limited to the axisymmetric Phase I models at this time.

3. The Advisory Group will furnish NRC and Sandia with information on the following items:
   a. particular penetration types which should be considered for inclusion in the Phase II 1/32 tests and the 1/8 scale test, and

b. recommendations on computer codes which should be employed in the analysis portion of the program.

This information, along with any other items which the members of the Advisory Group deem pertinent, may be sent directly to Sandia by the individual Advisory Group members. Sandia will then periodically transmit these comments to all concerned parties.