UNITED STATES GOVERNMENT

Memorandum

TO : Roger S. Boyd, Assistant Director for Reactor Projects, DRL
THRU: Robert L. Tedesco, Chief Reactor Project Branch 2, DRL

DATE: MAY 18 1967

FROM : K. Woodard
Reactor Project Branch 2, DRL

SUBJECT: MINUTES OF MEETING WITH PG&E APRIL 20-21, 1967, TO DISCUSS DIABLO CANYON REACTOR - DOCKET NO. 50-275

On April 20-21, 1967, representatives of Pacific Gas and Electric Company met with the staff and its consultants to discuss the Diablo Canyon plant design. The following persons attended:

AEC

M. M. Mann, REG
R. L. Tedesco, DRL
J. Newell, DRL
M. Rosen, DRL
K. Woodard, DRL
R. Waterfield, DRL
I. Spickler
F. Schauer, DRL
J. E. Hard, CO

AEC Consultants

W. J. Hall, Newmark & Assoc.
H. W. Coulter, USGS
L. M. Murphy, USC&GS

PG&E

J. C. Morrissey
D. V. Kelly
J. O. Schuyler
W. J. Lindblad
B. W. Shackelford
R. B. Bettinger
S. Peters
P. S. Crane

PG&E Consultants

J. A. Blume, Blume & Assoc.
P. L. Horrer, Marine Advisors, Inc.
R. H. Jahns, Stanford University
S. W. Smith, Caltech

Westinghouse

E. S. Beckjord
J. Stadelman
F. M. Moschini
G. A. Harstead
R. A. Wiesemann
W. Bezella

Westinghouse (continued)

E. Paxton
J. W. Dorrycott
R. A. Dean
R. C. Nichols
W. F. Schmauss
J. Moore

Seismic Design

The first topics discussed included the basis for the magnitude of earthquake acceleration proposed and the associated design response spectra. J. Blume detailed the approach used to obtain the earthquake magnitude. Basically, two methods are applied which are based on empirical studies and take into account measured conditions at the site such as shear velocity and density of the underlying material. The results were compared with a third method proposed by Housner. The overall results predicted an average of 0.13g with a worst case extreme of 0.25g for the "B" earthquake proposed, which would govern the containment design. W. Hall commented that the methods used for this extrapolation were only studies and were not intended for design use. Dr. Blume agreed but believes that they do represent a realistic approach to assigning earthquake magnitudes.

For the close in (or "D" earthquake) Dr. Blume predicts an acceleration of 0.2g; however, the design response spectrum proposed peaks in the short period range such that it does not govern the containment design. Mr. Murphy stated that he would prefer that this earthquake not be considered to be so close to the site but should be located further away since it originates as an after shock of an earthquake some distance from the site. Mr. Murphy does agree with the 0.2g acceleration, however, he does not believe that the response spectrum would be much different than the "B" spectrum (which governs containment design).

An important point which Dr. Blume continued to reiterate was that the foundation material is good bedrock which is generally believed to result in less amplification of seismic waves. In his opinion, if the plant were founded on alluvium the spectrum could well be amplified by a factor of 2 or 3.

In summary, it was agreed that the acceleration should be 0.2g for design and a maximum of 0.4g, but that the response spectrum proposed would need to be modified. Dr. Blume stated that he would consider proposing a revised spectrum. We indicated that we would continue to study this problem in light of the material received at this meeting.

Geology

The applicant was requested to present a plot of the plant layout, locating the trenches and the known faults in relation to plant structures. Dr. Jahns said that upon inspection of the trenching he had identified some minor faulting in the vicinity of the proposed location for the containment foundation. He does not believe that these faults will reduce the strength of the bedrock as foundation material. Both Drs. Jahns and Coulter believe that these faults are inactive and are more than 100,000 years old. We

discussed the significant fault exposed at the seawall and established that it did not appear in any of the trenching in the vicinity of the foundation. In Dr. Jahns's opinion, this larger fault does not run through the site but probably passes to the northwest; the visible smaller faults in the trenches could be branch faults of this larger one but are not of concern to him.

It was established that if the containment were relocated (to move off of the small faults) it would probably lie on similar faults in the new location. Thus, Dr. Jahns concludes that the present proposed location is adequate. They do not intend to do further trenching at the risk of uncovering geologic structures which could lead to additional speculation and possibly delay the project. It was suggested that the exposed fault at the seawall be traced by further trenching to establish its exact location in relation to the containment. The applicant stated that they did not believe this was necessary and that further information of this type would only complicate a contested hearing.

Dr. Jahns stated that none of these faults was similar to the Bodega or Malibu faults. Dr. Coulter agreed with the statements and findings made by Dr. Jahns.

Tsunami

The applicant's consultant on tsunami (Dr. Horrer) presented his method of estimating the maximum high and low water levels resulting from tsunami generated both close in and at great distances. He stated that the particular characteristics of the small Diablo cove and ocean bottom would not amplify a tsunami. These characteristics are based on calculations and measurements of natural wave periods observed at the site. Diablo cove was compared with that at Avila, a few miles south, where fairly large changes in water level have been observed. It was found that the response characteristics of Avila would result in amplitudes 3 to 10 times greater than Diablo cove. In summary, Dr. Horrer stated that in most cases large tsunamis can be explained by studying the characteristics of the coastline. He does not believe that Diablo cove has characteristics which could cause a water level in excess of 18 feet above the mean low water level or a rundown of more than 9 feet in the event of a tsunami.

Mr. Murphy spoke on this topic and presented comments submitted by Gaylord Miller, a tsunami expert of the USC&GS. Dr. Horrer stated that he could respond to all of Mr. Miller's comments if desired. We stated that Mr. Miller's comments would be submitted in a request for additional information.

Structural Design

Dr. Hall and F. Schauer discussed the design of the containment and other structures with the applicant. A list of 15 comments submitted by

Drs. Newmark and Hall (and supplied to PG&E prior to the meeting) served as the agenda for this discussion. The significant topics discussed included:

(1) The earthquake response design spectrum.

(2) The dynamic analysis including damping factors to be used.

(3) Design of isolation valves as Class I.

(4) Stress limits on design of Class I equipment.

(5) Local yielding in the containment due to thermal loads.

(6) Reinforcement patterns in various areas of the design.

(7) Quality control and testing procedures.

(8) Ultimate failure analysis

We indicated that additional information would be requested in each of the areas discussed to confirm information obtained at the meeting.

Instrumentation and Control

V. Moore briefly identified the areas in which he would probably require amplification concerning instrumentation, control and power systems. No unique problems in this design area are apparent since these systems will be designed to the same criteria used for other recent PWR's.

Turbine Missiles

Westinghouse stated that the low pressure turbine was essentially identical to that evaluated for other recent PWR's and failure would result in the same size and energy missiles. We stated that we would ask for confirmation of this and an evaluation of the ability of the containment and control room to withstand the missile generated.

Plant Systems

The design of the various plant systems was discussed. Topics of this discussion included:

(1) Location and protection of all Class I equipment.

(2) Interior missile shielding.

(3) Radiation protection criterion in auxiliary building (post accident).

(4) Containment access provisions during operation.

(5) Motor control centers.

(6) Ventilation systems.

(7) Boron injection system.

(8) Design details of diesel generators.

(9) Leakage characteristics of the steam line isolation valves.

(10) Isolation valve design and criteria - provisions for testing.

(11) Thermal shock to primary system and reactor vessel due to safety injection. (It was agreed that a topical meeting would be set up.)

(12) Control rod housing failure leading to failure of an adjacent housing.

(13) Design of system which will allow net load rejection.

(14) Design for pipe whipping.

(15) Design of core internals to withstand accident and seismic loads.

We indicated that additional information could be required in these areas.

Core Physics

Since this reactor is to have a power density 18% above that of Indian Point II, we pursued the core physics and thermal aspects of the design. The increase in power is due to significant flattening of the flux both radially and axially but the linear heat generation has only varied from 18.5 Kw/ft to 18.9 Kw/ft. According to Westinghouse, the new checkerboard fuel arrangement does not contribute significantly to the flatter flux. It does, however, help to reduce peaking in the second core which is not a checkerboard configuration. The reduction in axial peaking is due in part to the incorporation of "part rods" which serve primarily for coping with possible xenon oscillations. The most significant reduction in the total peaking is due to a more than 10% reduction in the radial peaking factor. Westinghouse claims that no physical core changes have been made to arrive at the new value, but that they feel more confident

about being able to achieve a power shape below this design limit. When questioned about Indian Point II, they stated that without making any changes they could probably achieve the same flattening.

Judging from the conversation with Westinghouse, it appears that the problem (in their opinion) is not one of being able to achieve the flattening but rather the potential increase in probability of xenon oscillations due to the increased power density. The design of the part-rod for damping these oscillations was presented. There will be 8 such rods--two in each quadrant--and they will be in addition to the normal complement of control rods. The poison section will comprise a 3 foot length at the bottom. Westinghouse is not certain of the normal position of these rods at this stage of design. The worth of an individual rod will be less than 0.3% delta-k/k and they will probably be moved as a bank. No reduction in positive moderator coefficient is expected as a result of using the part-rods. The fuel enrichments have been increased since the application was filed. Since the application contains no discussion of the part rods and other aspects of the core, PG&E has agreed to submit an amendment describing the part rod system and the basis for confidence in the design of the new core.

Clad Damage Limits

Fuel design was discussed and damage limits identified. They expect the maximum burnup to be 45,000 MWD/ton and it could be these rods which receive the highest thermal flux. The fuel is designed to the yield stress of 40,000 psi based on unirradiated Zr-4, and for a total strain of 1%. The pellet-to-clad gap is 6.5 mils (cold), and the design is for 0-pressure contact at the hot spot. The gas release is estimated to be 20% of the total based on experiments.

In terms of damage limits, a clad strain of 1.7% is considered to result in full failure. Centerline melting is assumed to occur at 24 Kw/ft; failure is predicted at 28 Kw/ft. At this point (28 Kw/ft) less than 30% of the fuel diameter would be molten.

We tried to establish the basis for Westinghouse's confidence that at the transient overpower limit of 112% or 21.3 Kw/ft there would be no significant fuel failure. Westinghouse cited tests at Hanford and Chalk River which provide confidence that there will be no damage at this magnitude. The standard Westinghouse elements will be tested in the Zorita reactor which is expected to be operational next year. The design power of the Zorita test section will be 20 Kw/ft. Westinghouse stated they would attempt to gain operating experience at 21.3 Kw/ft prior to operation of this plant. We intend to explore this area further based on the results of the TVA review.

Emergency Core Cooling System

The applicant stated that it would provide a core cooling system capable of preventing core melting (calculated) for all break sizes. These calculations would assume that no adverse change in the core cooling configuration had taken place, such as rod bowing or bursting. Curves were presented showing water level as a function of time. For the double ended break with 3 out of 4 accumulators operating , the core bottom was covered in 18 seconds and the hot spot in 35 seconds. Without core cooling melting starts in 35 seconds; 75% of the tubes are calculated to burst at temperatures between 1250°F at pressures of about 1000 psi. Westinghouse intends to do clad bursting tests to investigate the effect of such failure in regard to cooling.

The preliminary results did not assume a positive moderator coefficient. The staff expressed its concern that all cases should be analyzed using the positive coefficient prior to the construction permit.

We indicated that questions would be asked concerning core cooling.

Containment Design Basis

Since the power density is higher for this case than Indian Point II for the same size and pressure containment, the margin of the containment is reduced. In terms of the containment capability curves developed for Indian Point II, the amount of metal-water reaction allowable would be reduced from 77% to 72% in 2000 seconds. We discussed a new method of developing a containment capability curve in terms of energy. A topical meeting will be held to discuss this method.

Regarding the core transient assuming no core cooling, Westinghouse presented some interesting results. In terms of metal-water reaction with unlimited steam availability, following the parabolic rate equation, the total reaction assuming the clad stands in place until 3375°F was 24% and assuming the clad stands with 4800°F was 34%. The total time for all of the clad to slump was 1000 seconds. In previous calculations it had been assumed that the reaction was steam limited based on the supply of steam available from slumping fuel into the water below the core. The amount of reaction reported was only slightly less than the unlimited case. Thus, in their model for containment pressure transients (used for all Westinghouse PWR's) the core is only slightly steam limited.

Engineered Safety Systems

It was learned that several changes have been made in the cooling water systems for safeguards since issuance of the PSAR: The basic change was to move the fan-coolers from a separate coolant loop to the component cooling loop which also supplies the residual heat exchangers. With

this set-up, a failure in the component loop could preclude core and containment cooling altoghether after the first 45 minutes of an accident. It was strongly urged that some sort of a backup cooling system be provided for both fan-cooler and residual heat exchanger cooling water.

With regard to the thiosulfate injected containment spray system, there appear to be many characteristics of the system which are untried and will require development work. Significant items include:

(1) method of preventing mixing of the water which is used to force thiosulfate out of its storage tank

(2) effect of particulates on spray effectiveness

(3) possible discrepancy in applicant's calculated removal efficiency due to pressure effects

(4) possible coalescense of water droplettes

(5) relocation of spray nozzles in a position where better mixing would take place.

The fan-coolers will be of the finned type and we indicated that justification similar to that given for the CPL case would be necessary..

We indicated that questions would be generated concerning safeguards systems.

Safety Evaluation

Dose calculations for various accidents were discussed. Westinghouse stated that there was a mistake in the reported doses, however, the difference was not significant. We indicated that we would require more details concerning the steam line break accident. J. Moore stated that this could be provided for the no stuck rod case but not for the stuck rod case since this would require a more complete core design than now exists. We stated that the results of this calculation were required to assess the necessity for containment isolation in the event of steam line break since fuel failure will occur.

Westinghouse stated that the new core design would not significantly affect other reactivity accidents such as rod ejection, rod drop or positive moderator effects. They were informed that we would require an evaluation of the reactivity effects due to shaking and fuel relocation in the event of an earthquake or MCA.

Summary

At the conclusion of the meeting we indicated that the following course of action would be taken:

(1) We would expect an amendment to be submitted soon concerning the new core and part-rods,

(2) We would generate questions relating to the site and structural design which would be discussed with the applicant prior to issuance, and

(3) Questions in the other areas would follow later.

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