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5/12/64

Edson G. Case, Acting Director
Division of Reactor Licensing

ACRS MEETING ON BODEGA BAY ON MAY 8, 1964

50-205

During the May ACRS meeting on Bodega Bay, PG&E was asked to describe the proposed design of the containment system, particularly with respect to its ability to withstand vibration and displacement effects of a large earthquake occurring at or near Bodega Head on the San Andreas fault. Dr. Housner, PG&E's seismological consultant, sketched a design on the blackboard which was generally similar to that described in Amendment No. 7 of the PG&E application. He indicated that the clearance between the wall of the containment vessel and the rock interface was approximately 18 inches. He stated that a movement of 12 inches along the Shaft fault would result in a rock movement towards the containment vessel of only 8 inches, since the fault is on a minor chord of the reactor pit. He stated that this movement would be absorbed by the frangible material between the containment vessel and the rock and would result in little if any damage of the concrete side of the containment. Housner went on to indicate that even greater movements, up to as much as two to three feet, could be tolerated along the Shaft fault without loss of containment integrity or the ability for safe reactor shutdown because of the orientation of the Shaft fault in the reactor pit and because of void spaces interior to the containment. However, he gave little if any quantitative indication of what interior damage inside the containment might be expected if the movement along the fault were great enough to crush the containment walls. When asked about vibration design, Housner listed two different values of acceleration to be applied at the top and bottom of the containment vessel. The relation of these numbers to the maximum expected ground acceleration of .33 g listed in PG&E Amendment No. 6 was not apparent to me.

Dr. Newmark was later asked by the ACRS his opinion as to whether the PG&E design represented an acceptable approach from a vibration and displacement standpoint.

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His response indicated that although he had some specific reservations with the PG&E design, particularly with the vibration aspects at high frequencies, he believed that it was possible to provide a design that would withstand the expected earthquake effects, including a relative displacement of two feet. He stated that in his opinion the vibration criteria were about 25% too low in the high frequency region.

This oral judgement expressed by Dr. Newmark at the ACRS meeting was at variance with my previous understanding of his opinions. My understanding was primarily based on discussions with him in a meeting at Bethesda on April 14 with members of the ACRS, and a subsequent meeting in Harold Price's office that afternoon in a discussion attended by Price, Mann, Lowenstein, Henderson and Case. At that time I understood Dr. Newmark to believe that the vibration criteria proposed by PG&E in Amendment No. 6 were approximately 50% too low in the high frequency region. Also, he stated that although he believed that it might be feasible to provide a design suitable for withstanding about one foot displacement, such a design would be significantly different from that described by PG&E in Amendment No. 7. Further he indicated that the ability to design for displacements of two feet or greater was a much more difficult, if not impossible, undertaking.

In a private discussion that I held with Mr. Williamson on the same date, I asked him whether he was still concerned with the potential effects of aftershocks on the containment structure after the frangible material had been crushed by an assumed large displacement. He told me that he had gathered from Housner's presentation that there had been some change in the design proposed by PG&E at the ACRS meeting from that described in Amendments 6 and 7, which resulted in taking no credit for the restraining effects on the containment walls of the surrounding rocks and sediments. For this reason Williamson stated that his comments on PG&E's Amendment No. 7 with respect to this point, which were furnished to the regulatory staff on April 21, should be disregarded. He did indicate, however, that his understanding of this matter was not too clear and that he felt the design proposals of PG&E should be documented in writing in much more detail.

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Draft
R. A. Williamson
8/20/64

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Bodega Bay Atomic Park

Comments on Amendment 8

The following comments are offered regarding this amendment.

1. Provisions for Relative Displacement

The applicant proposes to provide the flexibility needed in vital "umbilical" features to withstand a three foot relative displacement between the reactor building and adjacent structures. This proposal appears to be entirely feasible in the case of inherently flexible elements such as cable, and conduit and low pressure piping of small diameter. If the item does not require lateral support to resist effects of earthquake vibrations, the measures needed in these cases are not elaborate, and consist largely of providing slack or free length and avoiding any detrimental constraints.

To preclude degradation of reliability, structurally significant plastic strains should not be permitted in vital umbilical features. Such a requirement calls for more special measures to increase inherent flexibility as, for example, flexible joints in pipe.

The steam line from reactor to turbine is an example of this situation, although the steam line, perhaps, cannot be considered as vital as other features, because of the presence of check valves to

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minimize the consequences of rupture. In the case of the steam line, flexibility is insufficient to tolerate a three foot displacement without development of plastic strains, based on the configuration shown in the PHSR. Therefore, if reliability comparable to that of Class 1 items is required, the contemplated design would require modification to incorporate greater flexibility. Bellows joints in this line may afford a means of absorbing a three foot displacement and withstanding the effect of earthquake vibrations at the same time without overstress.

There are certain limitations in the use of such joints, particularly with regard to the combination of pressure, diameter and movement capability. The 1100 psi pressure of this installation, 20 inch pipe diameter, and a rotational motion capability of about 3° to 4° constitute requirements beyond the limits of standard off-the-shelf components, and call for special design. While there is considerable reason to believe that a bellows joint can be designed for these conditions, it has not been possible to positively verify that this is so. The applicant states that the steam line, (presumably as shown in the PHSR, of carbon steel material, and without intermediate joints) will absorb a three foot displacement without failure, but recognizes that the stresses are greater than the yield stress. Presumably, also the computed values approach the ultimate tensile strength of the material. (It is to be noted that computed values of stress above yield are fictitous and do not accurately indicate structural behavior). The applicant's computation evidently implies the complete absence of earthquake bracing between the extreme ends of the pipe. Otherwise, the restraining forces imposed on the pipe by the bracing would lead to a computed stress greater than ultimate for carbon steel.

The applicant's concept apparently visualizes yielding of pipe and supports. A building structure of ductile material can tolerate strains at least several times the strain at yield. In most piping systems, too, a single self-limiting cycle of yielding due to thermal effects is an accepted possibility at initial startup of the system. On the other hand, the behavior of building structures under external loads causing strains far above yield has been studied extensively; in the case of piping, no such body of knowledge exists. Furthermore, the biaxial stress condition in piping reduces ductibility to some extent. It is quite possible that the version of the steam line as contemplated by the applicant in Amendment 8 could survive the displacement and earthquake effects in an overstrained condition without actual rupture. However, the probability that this is so is not beyond a reasonable doubt and is too low to be acceptable if the integrity of this line is considered as being absolutely vital.

An important related problem is the integrity of the valve located just outside the containment. Protection from high moments, thrusts, and shears may not be capable of achievement solely by using "adequate anchors and bracing beyond the double isolation valves", but may require, in addition, more flexibility in the pipe than now exists.

In principle, the relative displacement problem might be avoided by anchoring the turbine building to the reactor structure, but this creates a number of other problems. Among these are the transfer of forces at the junction and provisions for differential settlement and sliding of the turbine building.

2. Reactor Containment Structure

The reactor substructure (cylindrical reinforced concrete enclosure) is extremely massive, with exterior walls at least five feet thick, and has numerous floors and radial walls. Gravity, operating and seismic loads, and additional loads due to displacement do not cause severe stresses in this structure. Therefore, if reinforced with sufficient reinforcing steel to insure ductile behavior in resisting the imposed loads, there is a high degree of assurance that this structure would remain undamaged under the simultaneous effects of earthquake vibrations and displacement, up to the point where the displacement brings the wall of the pit into contact with the structure. Beyond this point, there is the possibility that the containment wall would be breached locally at locations of point or line contact.

3. Equipment Within Containment Structure

It is possible to design the emergency diesel generator, station battery, and associated controls to resist the vibrations transmitted by the structure. Equipment of this nature has been designed to survive shock and vibration environments in ships and submarines much more severe than the earthquake effect considered here. Where integrity is dependent upon functioning of umbilical features, the design of such features should meet the requirements stated in Section 1.

4. Remote Power Sources

It is questionable whether transmission of power from remote sources can be considered as reliable as on-site power, particularly with regard to the 220 Kv lines crossing the San Andreas fault. Destruction of towers in the fault zone is a possibility if located on the rupture plane, and is very likely more credible than faulting at the site itself. Rupture of lines or tower failure due to the large horizontal displacements known to occur on the San Andreas fault could conceivably happen in the case of short spans.

Collaspe of transmission towers due to earthquake induced landslides must also be considered at every tower along any portion of the line where the terrain is susceptible to such slippage. Existing towers and substations located within 35 miles or so of the San Andreas fault may be subjected to ground motion severe enough to cause major damage and loss of function, if not properly designed for this contingency.

In spite of previous earthquake damage to California power facilities, California power companies as of 1952 had not applied anti-seismic measures to existing installations throughout the entire system. Because of this, substations and other electrical equipment suffered severe damage in the Kern County earthquake of 1952. If the Ignacio substation referred to in the PHSR (page III-25, Section K-2) is existing, it may be no more seismic resistant than the damaged substations mentioned above. Needless to say, dependability of the emergency power supply is reduced to the extent that reliance is placed on such features.

Reliability of the 12 Kv line is subject to the considerations just discussed in connection with the 200 Kv line. Here the credible fault displacement is much less, although the spans may also be shorter.

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ltr transmitting 5 copies of comments relating to Amendment 8 of Bodega Bay application

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ENCLOSURES: Copies given to Doan, Boyd, Mann, Haddock

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REMARKS:

U. S. ATOMIC ENERGY COMMISSION — MAIL CONTROL FORM — FORM AEC-326S (8-60)