PSEG Public Service Electric and Gas Company

80 Park Plaza, Newark, NJ 07101 / 201 430-8217 MAILING ADDRESS / P.O. Box 570, Newark, NJ 07101

Robert L. Mittl General Manager
Nuclear Assurance and Regulation

May 8, 1985

Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
7920 Norfolk Avenue
Bethesda, MD 20814

ATTN: Mr. Albert Schwencer, Chief
Licensing Branch 2
Division of Licensing

Gentlemen:

HOPE CREEK GENERATING STATION
DOCKET NO. 50-354
RIVERBORNE MISSILES SUPPLEMENTAL INFORMATION

A January 9, 1985 letter from NRC transmitted questions on information PSE&G submitted on September 17, 1984 on potential riverborne missiles. Responses to these questions (except for question 3) were transmitted to you on January 31, 1985 and February 22, 1985.

Attached is our response to question 3. This completes our responses to your questions and we are available at your convenience to discuss our responses with members of your staff so that this open item can be closed out at an early date.

Very truly yours,

R L Mittl

Attachment

C D. H. Wagner (w/5 sets of attach.)
USNRC Project Licensing Manager

A. R. Blough (w/attach.)
USNRC Senior Resident Inspector

B001
1/1

HOPE CREEK GENERATING STATION
PUBLIC SERVICE ELECTRIC AND GAS COMPANY

Responses to Questions in January 9, 1985 Letter
Riverborne Missiles

Question 3

Discuss the ability of the service water intake structure to resist the impact of waterborne missiles (boats, barges, etc.) from upstream sources.

Answer 3

This question was answered in previous submissions to the NRC staff for upstream missiles originating due to:

1. System failure in normal commerce (e.g., an occasional runaway barge); and,

2. The forces associated with severe storms (e.g., hurricanes and high winds).

In subsequent meetings the NRC staff requested consideration of missile impact from upstream sources for scenarios which include single and multiple dam failures. These scenarios are examined below.

An Arthur D. Little, Inc. summary of the Bechtel analysis on the effects of floating missiles on the intake structure was presented in a previous memorandum dated March 15, 1985 (Reference 1). This memorandum is attached.

Two recent Dames & Moore letter reports (References 2 and 3) have developed probabilities of upstream dam rupture and of water levels and current velocities due to such failures and to concurrent flood and high tide events.

Based on these information sources, we can conclude the following:

- The maximum water level elevation at Hope Creek, due to multiple dam failing, one-half of the Probable Maximum Flood, and a 10% exceedance high tide, is 11.4 feet above the Natural Geodetic Vertical Datum (NGVD). Since the plant grade is 12.5 feet above the NGVD, there will be no potential floating missile hazards on the plant site due to the dam failure-plus-flood hazards.

- Since the dams are sited in locations influenced by different tectonic sources, the seismically-induced failure of the individual dams are considered to be independent events, i.e., the probability of two dams failing at the same time is several orders of magnitude lower than the probability of one dam failing from a seismic event. Consequently, the multiple dam failure scenario, with an overall probability

much less than 10^{-10} per year, is not a credible design scenario. As indicated in Table 2 of Reference 3, however, the maximum current velocities are the same for the one dam or multiple dam failure scenarios.

- The failure criterion assumed for the dam structures, based on a peak freefield ground acceleration of 0.24 g, causing a crest deformation of two feet, is extremely conservative. Furthermore, as indicated in Reference 2, there is considerable uncertainty as to whether such levels of ground motions are physically possible in the specific tectonic settings in which these dams are located.

- According to Table 2 of Reference 3, the highest possible current velocities associated with the postulated dam failure plus flood conditions scenarios is 16 fps at the Hope Creek Site. Assuming that a floating missile, travelling at 16 fps, impacts the travelling screen of the water intake structure, a limiting local acceleration level (1.6g) of the screen would be experienced with a maximum impact force equal to 530,000 lbs. This force would require a missile weighing over 26 tons. The width of the travelling screen, representing the target for the floating missiles, is approximately 60 ft.

- For a 26-ton missile travelling at 16 fps, the acceleration of the entire intake structure would be about 0.057g, less than the 0.1g acceleration assumed to be limiting.

- Even assuming a 10-inch round impact area for this missile, the concrete intake structure would not be penetrated, nor would spalling occur. For missiles with larger impact areas, the penetration or spalling potential would be even less.

- The only plausible "missiles" of sufficient size which would exist in reasonable quantities upstream of the Hope Creek site are marine vessels and loaded railroad tank cars lifted from their trucks (so they may float). Empty tank cars, without trucks, weigh 10 - 15 tons, typically. When full, weights up to 70 tons are possible. Similarly, marine vessels over 26 tons could be a potential concern.

Based on the above we conclude that in the event of a single dam failure, missiles of total weight 26 tons or more are of potential concern to the service water intake analysis.

Through site surveys, discussions with the United States Coast Guard, the U.S. Army Corps of Engineers, the Federal Fmergency Management Agency (FEMA) and the Federal Railroad Administration as well as contacts with large industries located on the Delaware River between Artificial Island and Philadelphia, we concluded that 26 ton floating missiles could include self-propelled marine vessels, loaded barges, and loaded rail tank cars. Each type of missile is considered in turn.

Self-propelled Vessels

As reported in Reference 4, there are on average 70 self-propelled vessels on the river on any given day. Although not all of them would be runaway missiles and some would have sufficient draft to ground prior to impacting the service water intake structure, we have conservatively assumed that all the self-propelled vessels are a missile of possible concern.

Barges

As reported in Reference 4, there are 150 barges on the Delaware River on any given day. Not all would be loaded or over 26 tons. Many would sink (e.g., open hopper barges) in a dam failure event. Nonetheless, we have conservatively assumed that all 150 barges are missiles of potential concern.

Rail Cars

In the event the postulated dam failure occurs, areas along the river banks near Philadelphia could experience up to 4 feet of water above grade. This is not really enough to float a loaded rail car. Also, the very few which could be floated would most likely be trapped by shoreside buildings and fences. It is highly unlikely that any rail car would impact the Hope Creek service water intake structure. Nonetheless, we have conservatively assumed that 50 rail cars could become missiles of concern.

Based on the above discussion, a highly conservative estimate for missiles of concern for the postulated event is 270 missiles.

As these missiles travel down-river they could reach the river bank (shoreline) and ground. There is more than 100 miles of shoreline (both banks) on the Delaware River between Philadelphia and Hope Creek. The Hope Creek service water intake structure forms a "target" of only 60 feet. The conditional probability of a missile striking this potentially vulnerable section is 60 ft/100 miles = 0.00011.

We now calculate the combined probability of a missile of concern striking the vulnerable portion of the service water intake structure under a single dam failure scenario.

Probability of dam failure*:		5×10^{-6}/yr
Number of missiles of concern:	x	270 missiles
Conditional probability of impact:	x	0.00011 impacts/missile
Combined Probability:		1.5×10^{-7} impacts/yr.

Given the highly conservative nature of each element in the calculation of this probability, the postulated scenario does not constitute a design basis event.

* This largest of the three dam failure probabilities is for the Downsville Dam.

References

1. "Bechtel Analyses on Impact Effects of Missiles on Intake Structure," Internal memorandum to A.S. Kalelkar from P. Athens, March 15, 1985.

2. "Annual Probabilities of Exceedance of Significant Dam Deformations" - F.E. Walter, Downsville and Cannonsville Dams. Dames and Moore, May 8, 1985.

3. Response to Question 1, January 9, 1985 letter from NRC to PSE&G (Schwencer to Mittl) submitted on January 31, 1985 (Mittl to Schwencer).

4. "An Analysis of the Likelihood of Waterborne Traffic and Other Floating Objects on the Delaware River Impacting the Hope Creek Generating Station in Severe Storms." Report to PSE&G by Arthur D. Little, Inc., Cambridge, MA, C-50918, September 1984.

MEMORANDUM TO: A.S. Kalelkar

FROM: Peter Athens

CASE: 50918

DATE: March 15, 1985

BECHTEL ANALYSIS ON IMPACT EFFECTS OF MISSILES ON INTAKE STRUCTURE

The Bechtel analysis assumes a "worst case" floating missile consisting of a 25,000 lb boat traveling at 20 mph and impacting the intake structure at its most vulnerable location over an impact area which is assumed to be 10 inches in diameter. Various characteristics of the impact itself and of the global (overall) and local effects on the intake structure are evaluated.

The process includes the following:

- The deceleration of the missile at impact is assumed to be the same as that of an automobile for which test data exists. The maximum force developed during the impact is

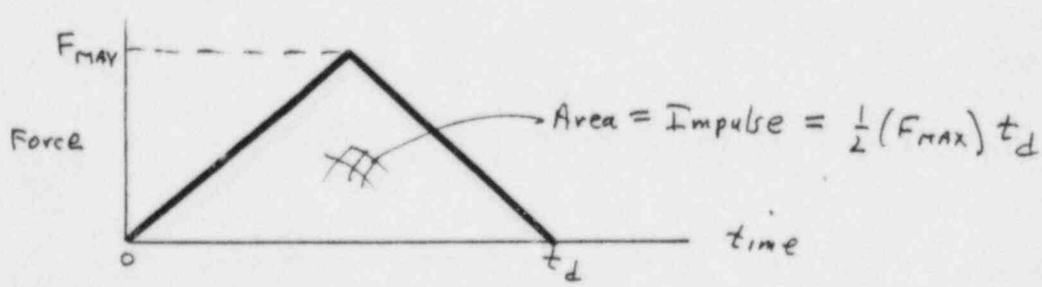
  $$F_{max} = 0.625\ V_s . W$$

  where V_s = missile impact velocity (29.3 fps for boat)

  W = weight of missile (25,000 lbs for boat)

  .. for boat, $F_{max} = 4.6 \times 10^{-5}$ lb

- The time history of the force due to the impact is assumed to be a triangular pulse, as shown



- Equating the impulse of this force to the momentum loads to the relation

  $$t_d = \frac{2}{.625g}\text{, or t 0.10 sec}$$

This is independent of the missile weight, velocity, and impact area, according to the Bechtel formulation. It is dependent on the assumption of the deceleration of the boat missile being the same as the deceleration of an automobile or derived from test data, and on the assumption of a completely inelastic collision.

o Next, the resistance of the concrete wall, based on the dynamic shear strength is given by

$$F_s = u_s A_s$$

where u_s = dynamic shear strength of concrete = 372 psi

and A_s = shearing area = $\pi T(D\&T)$

where T = concrete wall thickness = 30"

and D = diameter of impact area = 10"

(I think that A_s should be $\sqrt{2}\pi T(D\&T)$, but their formulation will give a conservative number.)

From their formula, $F_s = 1.4 \times 10^6$ lb.

Since $F_s > F_m$, the shear wall will not be punched through by the boat.

A general relation for other missiles would be that the shear wall will not be punched through as long as

$$F_{max} < 10^6 \frac{(30 + D')}{40}$$

where D' = diameter of impact area. I have allowed a safety factor of 1.4.

o Next, a check or perforation of the wall by the missile, assuming that it is a hard missile:

$$T_c = 5.5 \frac{W}{D^{1.8}} \left(\frac{V_s}{1000} \right)^{1.33}$$

If T_c is less than T, perforation will not occur.

o Spalling is not expected if T_c is less than $\frac{T}{2}$, so this establishes a more stringent criterion.

- A check on the vibratory acceleration of the entire intake structure from the missile impact shows that it is very unlikely that this could be a problem. A check on this is given by:

$$S = 2.63 \frac{W V_s}{W + 39,000,000}$$

where S = acceleration, of the intake structure, which should be less than 0.1g

(For the boat, S = 0.05g)

- The local acceleration level, due to missile impact, can be determined by

$$S_{local} = 149 \frac{F_m \quad (1.1)}{5.5 \times 10^8} \cong 3 \times 10^{-6} F_m \ (g)$$

For the boat, S_{local} = 1.37g

For other missiles, S_{local} < 1.6g, since this is the limitation for the most susceptible structure, the traveling water screen.

Applicability to Other Missiles

The method given above can be applied to other missiles like the ones discussed in the Bechtel report. Certain assumptions must be made, but overall, they would not be much different or less defensible than the ones that Bechtel have assumed. The limiting impact, according to this analysis, is the traveling screen, with a local acceleration level restricted to 1.6g. I believe that this restriction, which is based on the earthquake design load on the screen, is very conservative when assumed to be applicable to local impact loads. As interpreted by Bechtel, however, it means that missiles with somewhat higher maximum impact forces than the 25,000 lb. boat would exceed the screen's resistance capability. In all of the other aspects, i.e., perforation, spalling, overall acceleration of the intake structure, much larger missiles could be resisted as long as the impact area increases proportionally.