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PSEG
Power LLC

ND-2012-0020
March 23, 2012

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: **PSEG Early Site Permit Application**
Docket No. 52-043
Response to Request for Additional Information, RAI No. 53, Evaluation of Potential Accidents

References: 1) PSEG Power, LLC letter to USNRC, Application for Early Site Permit for the PSEG Site, dated May 25, 2010

2) RAI No. 53, SRP Section: 02.02.03 – Evaluation of Potential Accidents, dated February 23, 2012 (eRAI 6286)

The purpose of this letter is to respond to the request for additional information (RAI) identified in Reference 2 above. This RAI addresses Evaluation of Potential Accidents, as described in Subsection 2.2.3 of the Site Safety Analysis Report (SSAR), as submitted in Part 2 of the PSEG Site Early Site Permit Application, Revision 0.

Enclosure 1 provides our response for RAI No. 53, Question No. 02.02.03-2. There are no changes to the SSAR resulting from this RAI response.

If any additional information is needed, please contact David Robillard, PSEG Nuclear Development Licensing Engineer, at (856) 339-7914.

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NRO

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 23rd day of March, 2012.

Sincerely,

James Mallon
Early Site Permit Manager
Nuclear Development
PSEG Power, LLC

Enclosure 1: Response to NRC Request for Additional Information, RAI No. 53, Question No. 02.02.03-2, SRP Section: 2.2.3 – Evaluation of Potential Accidents

cc: USNRC Project Manager, Division of New Reactor Licensing, PSEG Site (w/enclosures)
USNRC Environmental Project Manager, Division of Site and Environmental Reviews (w/enclosures)
USNRC Region I, Regional Administrator (w/enclosures)

PSEG Letter ND-2012-0020, dated March 23, 2012

ENCLOSURE 1

RESPONSE to RAI No. 53

QUESTION No.
02.02.03-2

Response to RAI No. 53, Question 02.02.03-2:

In Reference 2, the NRC staff asked PSEG for information regarding the Evaluation of Potential Accidents, as described in Subsection 2.2.3 of the Site Safety Analysis Report. The specific request for Question 02.02.03-2 was:

> *RS-002 and RG 1.206 provide guidance regarding information needed to ensure that the potential hazards in the site vicinity are identified and evaluated in order to meet the siting criteria in 10 CFR 100.20 and 10 CFR 100.21.*
>
> *In SSAR Section 2.2.3.2.2, the applicant evaluated liquid/vapor explosions due to vessels on the Delaware River. The applicant relied on data from industry databases to identify large chemical explosions and evaluated the explosion of a vessel containing an estimated 116 tons of methyl tertiary-butyl ether (MTBE) vapor. Please clarify the relevance of this chemical vapor as compared to the chemicals that are documented to be shipped during 2003-2007 on the Delaware River. Please provide an evaluation of the potentially limiting chemical among those transported on the Delaware River with a maximum carried transport amount of 10,000,000 lbs (as bounding case), based on the guidance provided in RG 1.91 to calculate the minimum safe distance, or provide justification on why it is not required.*

PSEG Response to NRC RAI:

Two types of explosions are discussed in this RAI response. The first are explosions that occur on the vessel. This type of explosion will be referred to as an "on-vessel explosion." In an on-vessel explosion, the chemical explodes in the tank in which it is being transported by the vessel. The main chemical input needed for evaluation of an on-vessel explosion is the heat of combustion. The second explosion type is a delayed ignition, flammable vapor cloud explosion. This type of explosion will be referred to as a "flammable vapor cloud explosion." In a flammable vapor cloud explosion, the chemical spills from the tank in which it is being transported. The spill then evaporates or boils, which releases the flammable vapor to the atmosphere. Local weather might blow this flammable vapor cloud toward the PSEG site. If the concentration of the flammable vapor cloud is above the lower explosive limit (LEL), it might explode and adversely affect the PSEG site. Many chemical inputs are needed for the evaluation of a flammable vapor cloud explosion, including the density, vapor pressure, LEL, and heat of combustion.

On-Vessel Explosion

Methyl tertiary butyl ether (MTBE) is used as a representative chemical for an on-vessel explosion. MTBE is selected as representative for three reasons. First, per SSAR Table 2.2-8, MTBE is frequently transported on the Delaware River. Shipping data was collected from many different sources, each with their own commodity classifications. The data presented in SSAR Table 2.2-6, from the U.S. Coast Guard (USCG), does not

explicitly include MTBE, but is more complete and has a greater total mass than the data presented in SSAR Table 2.2-8, from the U.S. Army Corps of Engineers (USACE). It is likely that MTBE, as a component in gasoline, is included in the gasoline totals on SSAR Table 2.2-6. The USCG data is used for shipment sizes and total masses of each chemical for the probability analyses. The data from the USACE is used to validate that the assumptions and results are reasonable. Second, MTBE was the chemical that exploded in the largest recorded on-vessel explosion in the databases examined for this evaluation (see below). Third, MTBE is a hydrocarbon, as are six of the eight chemicals identified in SSAR Table 2.2-15. From an examination of references, hydrocarbons tend to have a relatively consistent heat of combustion (in energy per unit mass). Also, the heat of combustion for hydrocarbons is greater than almost all other chemicals (the one key exception is hydrogen, which is not transported on the Delaware River near the PSEG site). The two non-hydrocarbon chemicals in SSAR Table 2.2-15, ammonia and vinyl chloride, both have lower heats of combustion than do hydrocarbons. Therefore, an on-vessel explosion of MTBE vapor is a bounding explosion relative to the chemicals that are transported on the Delaware River.

To calculate the effects of an on-vessel explosion, data is used to determine the largest potential on-vessel explosion. Regulatory Guide 1.91, Rev. 1, states that the "largest probable quantity of explosive material transported by ship is approximately 10,000,000 pounds." A deterministic screening analysis showed that an on-vessel explosion of 10,000,000 pounds at the closest approach of the shipping lanes to the power block (0.9 miles, SSAR Subsection 2.2.3.2.2) would not meet the PSEG site safe standoff distance acceptance criteria. Per Regulatory Guide 1.91, "In cases where the distances ... are not sufficiently great to allow a conclusion... an analysis of the frequency of hazardous cargo shipments may show that the attendant risk is sufficiently low" (from Regulatory Guide 1.91, Rev. 1, pg 2, SSAR Subsection 2.2.3.2.1).

Per this guidance, an approach similar to a probabilistic analysis was generated to determine the hazard level of an on-vessel explosion of chemicals shipped by vessel on the Delaware River. This approach was previously discussed with the NRC on December 8th, 2009. In lieu of using 10,000,000 pounds, the Regulatory Guide maximum, as the explosion size, a "maximum possible explosion" is determined using available explosion data. This "maximum possible explosion" is selected such that any larger explosion can be shown with data to be probabilistically insignificant. In order to determine the size of the "maximum possible explosion," data for on-vessel explosions was collected.

As stated in Subsection 2.2.3.2.2 of the SSAR, the Bow Mariner explosion and sinking on February 28th, 2004, was the largest on-vessel chemical explosion in either the MISLE database (provided by the USCG) or the PHMSA database (maintained by the Department of Transportation). These two databases cover the date range 2001-2007 and 1999-2008, respectively. Several key pieces of information can be garnered from the report of the Bow Mariner incident. The Bow Mariner had recently emptied 22 tanks of MTBE to one port and was en route to a second port to deliver a large load of ethyl alcohol. Despite the fact that the Bow Mariner contained more than 3.5 million gallons

of ethyl alcohol at the time of the explosion (SSAR Subsection 2.2.3.2.1), only the recently emptied tanks of MTBE exploded (SSAR Subsection 2.2.3.2.2). The liquid ethyl alcohol did not explode. Liquid chemicals need to be oxidized to support a flame and to support an explosion. This has been documented in many sources including NUREG-1805 Section 15.3, the Handbook of Chemical Hazard Analysis Procedures, and The Society of Fire Protection Engineers (SFPE) Handbook of Fire Protection Engineering. Because only vapors of hydrocarbons can explode, the total mass available for the explosion will be significantly smaller than 10,000,000 pounds. For example, 10,000,000 pounds of gasoline vapor (density of 0.3244 lb/ft^3) would occupy a 30.8 million cubic foot tank, which is a tank that is 100 feet wide, 100 feet tall, and more than half of a mile long. This is not a realistic tank size for a shipping vessel on the Delaware River, where the shipping lane can be as shallow as 39.3 feet (SSAR Subsection 2.2.2.3.2).

Second, the explosion on the Bow Mariner took place across 22 separate tanks of MTBE with a slight delay between the explosions of each tank (SSAR Subsection 2.2.3.2.2). Observers reported hearing rapid bursts in succession. This suggests that the entire vapor mass of MTBE did not explode at exactly the same time. Therefore, the blast waves would be spaced slightly apart and each would have lower amplitude than a single detonation of the entire mass. The effect of several successive explosions was conservatively <u>not</u> accounted for in this analysis (SSAR Subsection 2.2.3.2.2). Instead, the entire vapor mass of all 22 tanks was treated as if it were in a single tank. The total vapor mass is estimated to be 116 tons of MTBE vapor based on the vapor density of MTBE and the reported offloaded volume of MTBE.

Third, the Bow Mariner incident was the largest on-vessel chemical explosion that could be found. This establishes that an explosion larger than the Bow Mariner is very unlikely. For conservatism in this analysis, it is assumed that the largest on-vessel explosion near the PSEG site is <u>six</u> times the size of the Bow Mariner explosion (SSAR Subsection 2.2.3.2.2). The "maximum possible explosion" used in this analysis is, therefore, 1,392,000 pounds. An on-vessel explosion larger than six times the biggest explosion identified in the PHMSA or MISLE databases, where the entire mass explodes in one blast, is considered probabilistically insignificant.

Flammable Vapor Cloud Explosion

For the flammable vapor cloud explosion, all eight chemicals in SSAR Table 2.2-14 are analyzed. These bounding chemicals are selected as the representative chemicals for the different commodity classes that are transported on the Delaware River, as shown in SSAR Table 2.2-16. For more discussion on the bounding chemicals for flammable vapor cloud explosions, see the response to RAI No. 51 (Question 02.02.03-1, eRAI 6284).

For the flammable vapor cloud explosion analysis, the possible spill sizes are segregated into ranges (SSAR Table 2.2-12). For each spill size range, the probability of a spill of that size is calculated using data from the MISLE database (see SSAR

Subsection 2.2.3.2.1). The largest spill range is listed as >322,000 gallons (SSAR Table 2.2-12). The largest spill size in the MISLE database was 3,629,529 gallons of ethyl alcohol from the Bow Mariner. In the supporting calculation, a maximum spill size of 4,000,000 gallons is used for the >322,000 gallon category. A spill of 4,000,000 gallons would likely be between 24,000,000 pounds and 40,000,000 pounds for liquids with densities between 6 lb/gal and 10 lb/gal. This maximum spill size is much larger than the 10,000,000 pounds recommended in Regulatory Guide 1.91, Rev. 1. It is appropriate to use this larger release volume, however, because the spill from the Bow Mariner was larger than 10,000,000 pounds. A sample flammable vapor cloud explosion analysis is shown in SSAR Table 2.2-13.

Associated PSEG Site ESP Application Revisions:

None.