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

Peach Bottom Atomic Power Station, Units 2 and 3
Renewed Facility Operating License Nos. DPR-44 and DPR-56
NRC Docket Nos. 50-277 and 50-278

Subject: Response to Request for Additional Information
License Amendment Request Concerning Non-Conservative Technical Specification Associated with the Amount of Liquid Nitrogen Storage

References:

1) Letter from P. B. Cowan (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission - License Amendment Request for Non-Conservative Technical Specification Associated with the Amount of Liquid Nitrogen Storage - dated June 25, 2010 (ML101790114)

2) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to M. J. Pacilio (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Units 2 and 3: Supplemental Information Needed for Acceptance of Requested Licensing Action Re: Liquid Nitrogen Storage (TAC Nos. ME4131 and ME4132)," dated July 30, 2010 (ML102110061)

3) Letter from P. B. Cowan (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission – Supplemental Information for License Amendment Request for Non-Conservative Technical Specification Associated with the Amount of Liquid Nitrogen Storage - dated August 16, 2010 (ML102310079)

4) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to M. J. Pacilio (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Units 2 and 3 – Request for Additional Information Regarding License Amendment Request Related to Liquid Nitrogen Storage (TAC Nos. ME4131 and ME4132)," dated October 21, 2010 (ML102861886)

By letter dated June 25, 2010 (Reference 1), Exelon Generation Company, LLC, (Exelon) submitted a License Amendment Request (LAR) for the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, requesting changes to the Technical Specifications (TS) to address non-conservative TS Surveillance Requirements (SR) associated with the amount of nitrogen available in the liquid nitrogen storage tank.

By letter dated July 30, 2010 (Reference 2), the U.S. Nuclear Regulatory Commission (NRC) requested that Exelon submit a copy of the supporting calculation PM-0375, Revision 4, *"To Establish Limiting Demand for N_2 for the CAD System and the SGIG System for Dual Unit Operation,"* to facilitate completion of the acceptance review. The requested information was submitted to the NRC as documented in a letter dated August 16, 2010 (Reference 3).

Subsequently, by letter dated October 21, 2010 (Reference 4), the NRC requested that Exelon provide additional information concerning vendor-supplied information used in the calculation (i.e., PM-0375, Revision 4) to determine the liquid nitrogen tank level to volume correlation values used. The attachment to this letter restates the NRC's question followed by Exelon's response.

Exelon has concluded that the information provided in this response does not impact the conclusions of the: 1) Technical Evaluation, 2) No Significant Hazards Consideration under the standards set forth in 10 CFR 50.92(c), or 3) Environmental Consideration as provided in the original submittal (Reference 1).

There are no regulatory commitments contained in this submittal.

If you have any questions or require additional information, please contact Mr. Richard Gropp at (610) 765-5557.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 6th day of December 2010.

Respectfully,

Pamela B. Cowan
Director - Licensing and Regulatory Affairs
Exelon Generation Company, LLC

Attachment: Response to Request for Additional Information - License Amendment Request Concerning Non-Conservative Technical Specification Associated with the Amount of Liquid Nitrogen Storage

cc: NRC Region I, Regional Administrator
NRC Project Manager, NRR - Peach Bottom
NRC Senior Resident Inspector - Peach Bottom
S. T. Gray, State of Maryland
R. R. Janati, Bureau of Radiation Protection, Commonwealth of Pennsylvania

ATTACHMENT

PEACH BOTTOM ATOMIC POWER STATION
UNITS 2 AND 3

NRC Docket Nos. 50-277 and 50-278

Renewed Facility Operating License Nos.
DPR-44 and DPR-56

Response to Request for Additional Information
License Amendment Request Concerning
Non-Conservative Technical Specification Associated with the
Amount of Liquid Nitrogen Storage

Response to Request for Additional Information License Amendment Request Concerning Non-Conservative Technical Specification Associated with the Amount of Liquid Nitrogen Storage

Background

By letter dated June 25, 2010, Exelon Generation Company, LLC, (Exelon) submitted a License Amendment Request (LAR) for the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, requesting changes to the Technical Specifications (TS) to address non-conservative TS Surveillance Requirements (SR) associated with the amount of nitrogen available in the liquid nitrogen storage tank. The proposed changes would revise TS SR 3.6.1.3, *"Primary Containment Isolation Valves (PCIVs),"* and SR 3.6.1.5, *"Reactor Building-to-Suppression Chamber Vacuum Breakers,"* to modify the required level for the liquid nitrogen storage tank. Specifically, the proposed changes would revise TS SR 3.6.1.3.1 and SR 3.6.1.5.1 to require the minimum amount of nitrogen inventory in the liquid nitrogen storage tank be maintained at $\geq$ 22 inches water column, or equivalent volume of $\geq$ 124, 000 standard cubic feet (scf), not the currently stated level of ≥ 16 inches water column (equivalent volume of $\geq$ 50, 000 scf).

By letter dated July 30, 2010, the U.S. Nuclear Regulatory Commission (NRC) requested that Exelon submit a copy of the supporting calculation PM-0375, Revision 4, *"To Establish Limiting Demand for N_2 for the CAD System and the SGIG System for Dual Unit Operation,"* to facilitate completion of the acceptance review. The requested information was submitted to the NRC as documented in a letter dated August 16, 2010.

Subsequently, by letter dated October 21, 2010, the NRC requested additional information in order to complete the review of the License Amendment Request (LAR). The NRC requested additional information concerning vendor-supplied information used in calculation PM-0375, Revision 4, in determining liquid nitrogen tank level to volume correlation values used. The specific question is restated below followed by Exelon's response.

NRC Question (RAI-01)

Provide justification that the vendor-supplied information used in Exelon calculation PM-0375, Revision 4, to determine the liquid nitrogen tank level/volume correlation for 16 inches of water column to 50,000 standard cubic feet (scf) and 22 inches of water column to 124,000 scf, as described in the application dated June 25, 2010, meets the requirements of 10 CFR 50, App B, Section III, "Design Control."

Response

The vendor-supplied documentation referenced in Calculation PM-0375, Revision 4, contains a *"for reference only"* note. Additional justification is being provided confirming that the vendor-supplied data for correlating 16 inches water column to 50,000 standard cubic feet (scf) and 22 inches water column to 124,000 scf is acceptable for use in support of the proposed TS changes.

The Exelon Quality Assurance Program (QAP) describes the planned and systematic actions necessary to provide adequate confidence that structures, systems, and components will perform satisfactorily in service. The QAP includes aspects on quality verification, which involves the examination of those physical characteristics of material, structure, component, or system which provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

An independent analysis was performed by qualified PBAPS engineering personnel in accordance with Exelon QAP requirements in order to validate and justify the vendor-supplied information discussed in Calculation PM-0375, Revision 4. This analysis was independently verified by a qualified individual and will be maintained as a quality record in accordance with QAP requirements.

The information discussed below describes the analysis methodology used to verify the level/volume correlation information supplied by the vendor as documented in Calculation PM-0375, Revision 4. The analysis performed was of sufficient scope and detail to satisfy the requirements of 10 CFR 50, Appendix B, Section III, *"Design Control,"* which stipulates *"...design control measures shall provide for verifying or checking the adequacy of design, such as by the performance of design reviews, by the use of alternate or simplified calculational methods, or by the performance of a suitable testing program...."*

In order to determine the amount of liquid nitrogen in the storage tank at a certain level, a conversion between inches of water column (provided by level indicators) and height of liquid nitrogen in the tank is required.

The level indicators on the liquid nitrogen storage tank utilize differential pressure (dP) instruments that provide the dP between the High Pressure Side and Low Pressure Side (reference leg) of the storage tank (see Figure 1 below) in inches of water column. The High Pressure Side is connected to the tank bottom to measure the pressure of the vapor space and liquid and the Low Pressure Side is connected to the vapor space. The following variables have been used to determine a correlation between height of liquid nitrogen and dP, as indicated by the level indicators.

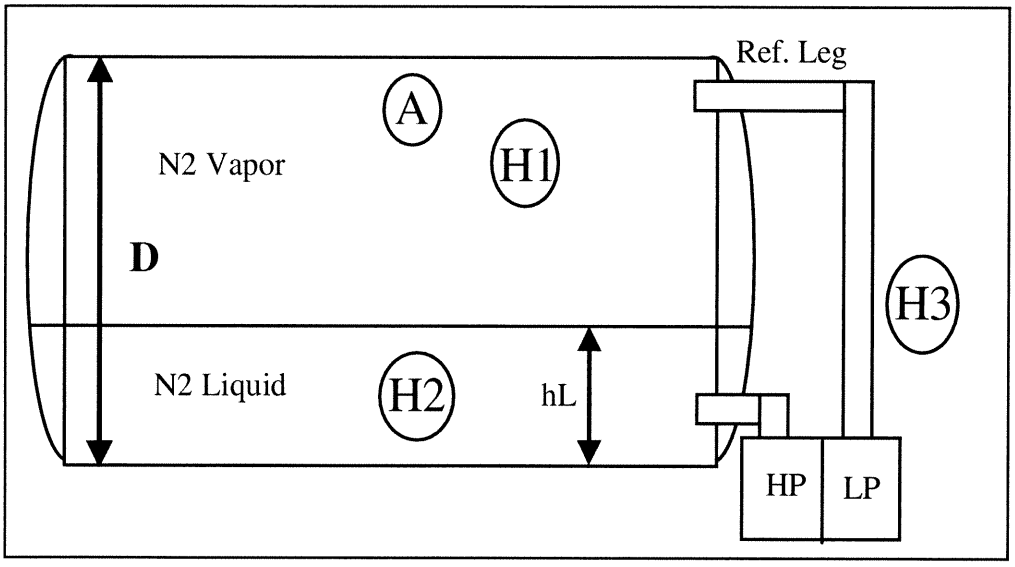

Figure 1

Variables

D = diameter (90 inches)
h_L = height of liquid (variable)
ρ_{V1} = density of saturated N_2 vapor
ρ_{V3} = density of N_2 in reference leg (LP side)
ρ_L = density of saturated N_2 liquid
g = gravity (32.2 ft/s^2)
A = Tank Pressure (0 psig, 170 psig, or 250 psig)
H1 = Vapor Elevation Head (ρ_{V1}*g*(D – h_L))
H2 = Liquid Elevation Head (ρ_L *g*h_L)
H3 = Vapor Reference Leg Elevation Head (ρ_{V3}*g*D)

Computation

dP = High Pressure Side – Low Pressure Side

High Pressure Side = A + H1 + H2
Low Pressure Side = A + H3

dP = (A + H1 + H2) – (A + H3)
dP = H1 + H2 – H3

$$dP = \rho_{v1} g(D - h_L) + \rho_L g(h_L) - \rho_{v3} g(D)$$

$$dP = gD(\rho_{v1} - \rho_{v3}) + gh_L(\rho_L - \rho_{v1})$$

Solving for h_L and including a conversion from inches of water column to psi for dP:

$$h_L = \frac{\left(dP * \left(0.036 \frac{psi}{in.ofw.c.}\right) - gD(\rho_{v1} - \rho_{v3})\right)}{(g(\rho_L - \rho_{v1}))}$$

The nitrogen vapor in the Low Pressure Side (reference leg) of the dP instrument was assumed to be at room temperature since a majority of the line is external to the tank and not insulated. The temperature of the nitrogen was conservatively assumed to be approximately 105 degrees F by engineering judgment. Using 105 degrees F is conservative since this temperature bounds anticipated room temperatures and results in a smaller calculated volume of liquid nitrogen at any indicated dP reading. The density of the liquid and vapor space in the storage tank was considered to be at saturated conditions since they co-exist in the same tank. The liquid nitrogen in the High Pressure instrument leg was assumed to have the same density as the liquid nitrogen inside the storage tank. This is considered acceptable given the short distance the leg travels outside of the tank to the level instruments. In addition, a higher temperature results in a less dense fluid and would cause a lower indicated dP. This establishes the means to convert the dP measurement provided by the level indicators to the height of the liquid

nitrogen in the storage tank. The tank volume at specific elevations was then determined using the following methodology:

Partial Volume of a Horizontal Cylinder

r = 45 inches
L = 205.75 inches

$$V = \left\{ r^2 \cos^{-1}\left(\frac{r - h_L}{r}\right) - (r - h)\left(2rh_L - h_L^{\,2}\right)^{\frac{1}{2}} \right\} L \qquad \text{[cu. in.]}$$

Partial Volume of Elliptical Heads

D = 90 inches

$$V = 0.5236 h_L^{\,2}(1.5D - h_L) \qquad \text{[cu. in.]}$$

The partial volume of elliptical heads equation accounts for both heads and does not need to be doubled. Both volumes are then combined and converted to gallons by multiplying the equation above by [(1 foot / 12 inches)^3 x (7.480519 gallons/ft^3)]. To convert from cubic feet (ft^3) of liquid nitrogen to the amount of gaseous nitrogen, the volume is multiplied by the density of liquid nitrogen and the specific volume of gaseous nitrogen at standard conditions (13.803 scf/lb).

A verification of the derived volume equations as a function of level was completed by comparing the total and half-full volume of the elliptical heads and cylindrical section of the storage tank. The above equations were compared to an approximation equation for the elliptical heads (V = 0.9545 x D^3) and the volume of a cylinder equation (V = PI/4 x D^2 x L). The methodology above yielded an error of less than 0.4% or 2.8 ft^3 when full and 1.4 ft^3 when half-full. Therefore, the above methodology for determining the volume of liquid nitrogen at various heights is considered acceptable.

The methodology discussed above was used to determine the volume of liquid nitrogen with the indicated dP by the level indicators when the tank is at 1 atm (0 psig). This resulted in the following graph (Figure 2):

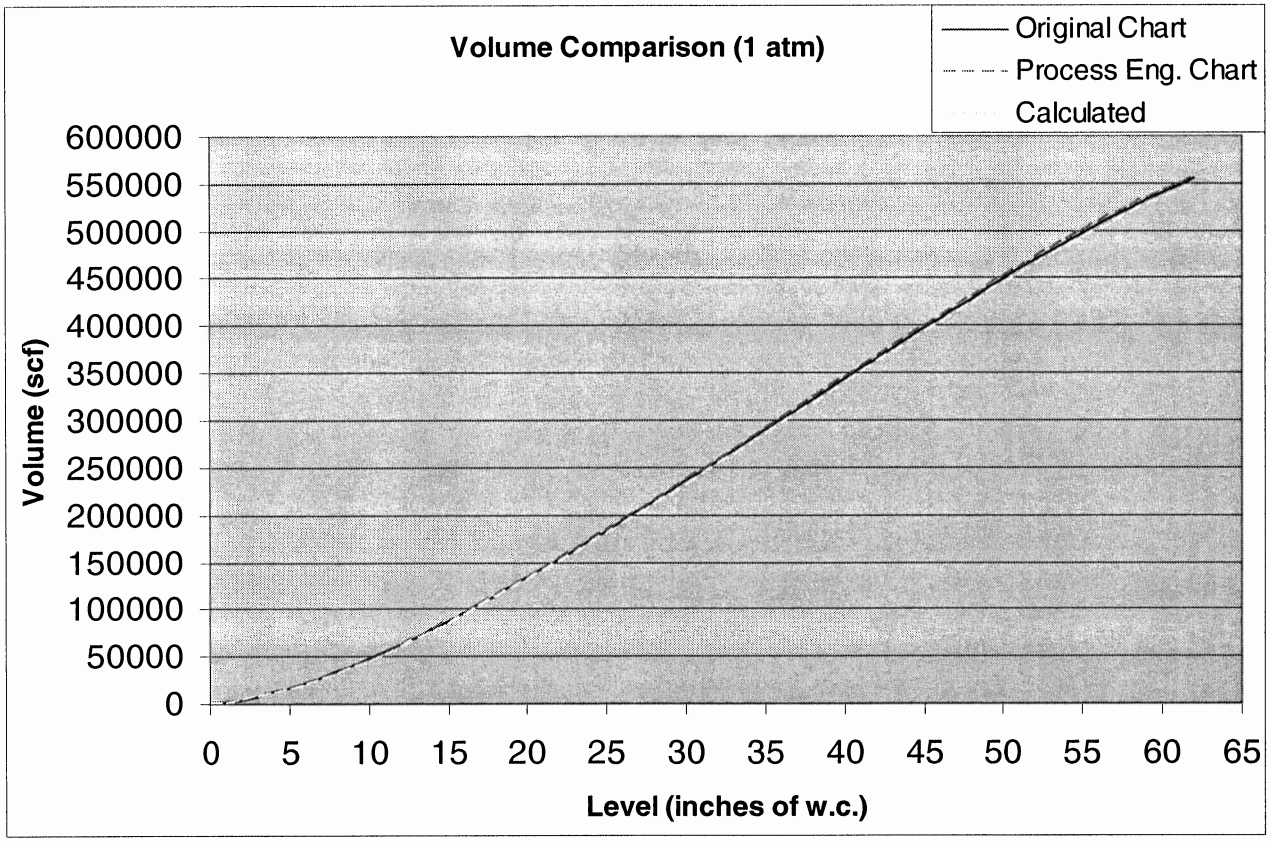

Figure 2

Figure 2 depicts the calculated, vendor-supplied (Process Engineering, Inc.), and original tank manufacturer's charts. The vendor-supplied chart (Process Engineering, Inc.) was developed in 1990 and used to confirm the original tank manufacturer's chart that was provided with the tank in the 1970s. It should be noted that there are no concerns with the validity of the original manufacturer's chart. The results show that the computation used to determine the volume of liquid nitrogen is accurate. In addition, the graph demonstrates that the original manufacturer's chart bounds the values calculated and that the calculated volumes are conservative. Some of the differences between the calculated and the vendor-supplied chart can be attributed to variation in the values used for density of the liquid and vapor phase of nitrogen. As a result of the above discussion, the vendor-supplied (Process Engineering, Inc.) one (1) atm chart is considered acceptable since the original manufacturer's chart is bounding or within 0.45% of the vendor-supplied (Process Engineering, Inc.) chart.

The same methodology was used for determining whether the vendor-supplied charts at storage tank pressures of 170 psig and 250 psig are acceptable for use. The results for 170 psig are as follows:

Volume Comparison with P = 170 psig						Gaseous Volume Difference (SCF)	Percent Difference
		Process Eng. Inc.		Calculated			
dP (Inches of w.c.)	Calculated Tank Level (in.)	Liquid Volume (gallons)	Gaseous Volume (SCF)	Liquid Volume (gallons)	Gaseous Volume (SCF)		
16	21.11	1008	74300	1127	82949	-8649	-11.64%
22	31.32	1857	136800	1984	146026	-9226	-6.74%

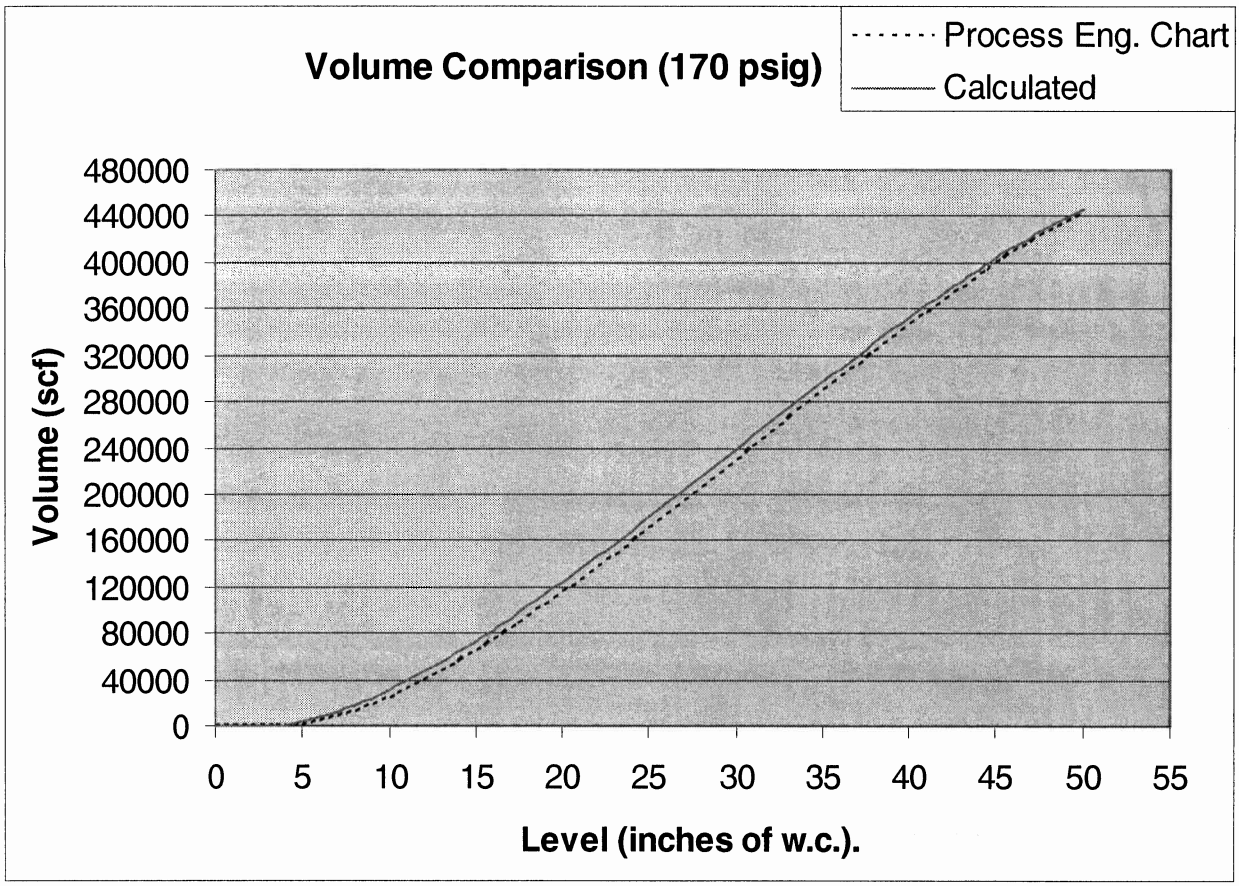

Figure 3

The volume comparison results for a storage tank pressure of 250 psig are as follows:

Volume Comparison with P = 250 psig						Gaseous Volume Difference (SCF)	Percent Difference
		Process Eng. Inc.		Calculated			
dP (Inches of w.c.)	Calculated Tank Level (in.)	Liquid Volume (gallons)	Gaseous Volume (SCF)	Liquid Volume (gallons)	Gaseous Volume (SCF)		
16	20.51	865	58800	1081	73300	-14500	-24.66%
22	32.28	1825	124000	2070	140402	-16402	-13.23%

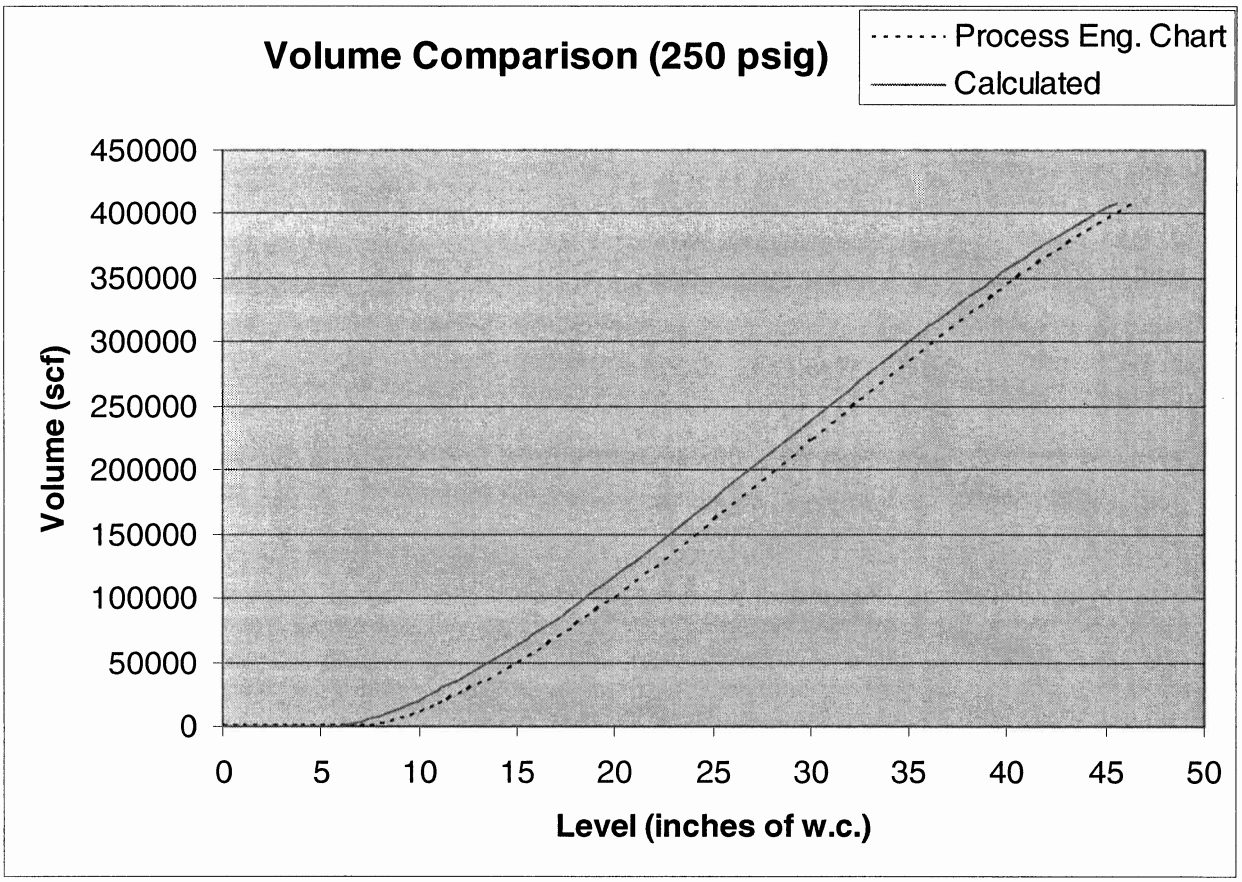

Figure 4

The results for a tank pressure at 170 psig and 250 psig show that the vendor-supplied charts are considered conservative (as indicated by a negative volume difference values) since the calculated values bound the vendor supplied values. In this case, less liquid volume at a given level is conservative since less inventory of nitrogen is available for SGIG system supply. In response to the large variation between the vendor-supplied charts and the calculated values as shown in Figure 4, a technical representative from Chart Inc. (formally Process Engineering, Inc.) and a technical representative from Air Products, Inc., were contacted to discuss the variation. It was explained that there are difficulties associated with determining the liquid nitrogen inventory using dP type level indicators. As a result, the vendor-supplied charts include conservative assumptions, and therefore, reduce the available amount of gaseous nitrogen able to be produced from the inventory of liquid nitrogen. In addition, the above computation is considered conservative since it does not account for the volume of nitrogen in the vapor space of the storage tank and underestimates the amount of nitrogen available. The 250 psig chart (Figure 4) is particularly important since it is used to support the proposed TS changes (i.e., liquid nitrogen storage tank level should be maintained at $\geq$ 22 inches water column, or equivalent volume of $\geq$ 124,000 scf at 250 psig). Using the 250 psig chart provides more conservatism since the tank historically operates between 175 psig and 210 psig and a higher tank pressure decreases the liquid nitrogen density and produces less available nitrogen.

Conclusion

The information discussed above verifies that the vendor-supplied charts presented in the Calculation PM-0375, Revision 4, is considered acceptable based on applying *"simplified calculational methods"* in accordance with 10 CFR 50 Appendix B, Section III, and Exelon QAP requirements. It was determined that the storage tank level correlated volumes in the vendor-supplied charts were similar or significantly less than those calculated. In addition, it was demonstrated that the corresponding amounts of nitrogen at 16 and 22 inches of water column at 250 psig are acceptable since the calculated values bound the vendor-supplied values. As a result, the 250 psig vendor-supplied data is considered acceptable in supporting the proposed TS change level/volume correlations (i.e., 16 inches of water column to 50,000 scf and 22 inches of water column to 124,000 scf) as discussed in the proposed LAR.