

Enclosure 3

Calculation of Atmospheric Dispersion Factors
Exclusion Area Boundary & Low Population Zone
for SQN Units 1 & 2

(6 pages)

**Sequoyah Nuclear Plant
Short-Term (Accident) Dispersion Estimates - PAVAN Modeling
Meteorological Episode: 2004-2013
Revision 1**

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This report documents the determination of the short-term atmospheric dispersion coefficients, expressed as X/Q , for the radiological consequence analyses at the Sequoyah Nuclear Plant (SQN) for specified time intervals at the Exclusion Area Boundary (EAB) and the Low Population Zone (LPZ), as required under 10 CFR 100 and 10 CFR 50. The calculations were performed using the PAVAN computer program, NUREG/CR-2858, which was developed and is used by the U.S. Nuclear Regulatory Commission (NRC) for this type of application. The PAVAN program implements the guidance provided in NRC Regulatory Guide (RG) 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants". The PAVAN model calculates X/Q values based on the theory that material released to the atmosphere would be normally distributed (Gaussian) about the plume centerline.

PAVAN Input

Using joint frequency distributions (JFDs) of wind direction, wind speed, and atmospheric stability class, the PAVAN program calculates X/Q values as functions of direction, distributed in 22.5-degree compass-point sectors, for six (6) averaging times at the EAB and LPZ.

The input parameters used in the PAVAN model are outlined in Table 1. A ten year period (January 1, 2004 – December 31, 2013) of SQN meteorological tower data were used as input to the PAVAN code. The meteorological tower data met the requirements of RG 1.23 and was validated in accordance with the TVA validation procedures (Environmental Permits and Compliance, Validation of Meteorological Data – Nuclear [EPC-SOP-9.2]). The data recovery over the 2004-2013 period was greater than 90 percent.

Table 1. PAVAN Model Input Parameters

Input Variable	Value	Reference
Containment Building Height	40.8 m	Drawing 41N712-1
Containment Building Min. Cross Sectional Area	1632 m ²	Drawing 41N712-1
Wind Sensor Height	9.73 m	SQN EDS manual
Lower-T Sensor Height	9.25 m	SQN EDS Manual
Intermediate-T sensor Height	45.99 m	SQN EDS Manual
Distance to EAB		
Release Zone 1	556 m	FSAR Table 2.3.4-1
Release Zone 2	600 m	FSAR Table 2.3.4-1
Release Zone 3	509 m	FSAR Table 2.3.4-1
Distance to LPZ	4828 m	FSAR Section 2.3.4
Type of Release	ground	FSAR Section 2.3.4
Building Wake Credit	yes	FSAR Section 2.3.4

Three levels of wind direction and wind speed were available from the SQN tower: A lower, 10-meter (m) level; a middle, 46-m level; and an upper, 91-m level. Based on RG 1.145, a ground release includes all release points that are effectively less than two and one-half times the height of adjacent solid structures. Since the SQN plant release points are less than two and one-half times the containment and turbine building heights, the release mode applied was classified as a ground-level release. For the ground-level release mode in PAVAN, the lower level of wind speed and direction (wind sensor mounted at 9.73 m) were used as input into the PAVAN model.

PAVAN requires meteorological data that is input in the form of JFDs of wind direction and wind speed by atmospheric stability class. The stability classes were determined based on the classification system given in Table 1 of RG 1.23. The vertical temperatures used to determine stability class were measured at approximately 9.25 m and 45.99 m above ground, and the lapse rates were calculated as degree Celsius (°C) / meter (m). The 2004-2013 wind data were input into PAVAN in terms of JFDs in number of hours, rounded to the nearest integer as required by the program.

According to RG 1.145, calms are classified as hourly average wind speeds below the vane or anemometer starting speed, whichever is higher. The SQN sonic sensor can report minimum non-calm wind speeds of 0.1 miles per hour (mph). Since calms were distributed into the first wind speed category in the JFDs, they were not manually distributed in the PAVAN input file. The upper bound wind speed categories used in the PAVAN analysis were defined as follows: ≤ 1.12 mph (0.50 m/s), ≤ 1.68 mph (0.75 m/s), ≤ 2.24 mph (1.00 m/s), ≤ 2.80 mph (1.25 m/s), ≤ 3.36 mph (1.50 m/s), ≤ 4.47 mph (2.00 m/s), ≤ 6.71 mph (3.00 m/s), ≤ 8.95 mph (4.00 m/s), ≤ 11.18 mph (5.00 m/s), ≤ 13.42 mph (6.00 m/s), ≤ 17.90 mph (8.00 m/s), and ≤ 22.37 mph (10.00 m/s). A conversion factor was used in PAVAN to convert the wind speeds to meters / second.

Consistent with the assumptions outlined in the SQN Offsite Dose Calculation Manual (ODCM) and Final Safety Analysis Report (FSAR), the onsite meteorological data is representative of the actual transport and diffusion characteristics of the site vicinity. No terrain adjustment factors were applied. The PAVAN model also requires containment building dimensions and distances to the EAB and LPZ. The containment building dimensions were provided in the SQN 41N712-1 engineering drawings. The distances to the EAB and LPZ were provided in the SQN FSAR.

Quality Assurance (QA) of PAVAN

PAVAN is not in the TVA-NPG software QA program, but it is widely utilized in the industry and is acceptable for use by the NRC. In lieu of the QA requirements, a test case from NUREG/CR-2858 Appendix B (Test Case #1) was modeled with the TVA-installed version of the PAVAN code to show that the model was performing as intended. As summarized in Table 2, the TVA test case results compared exactly to those in NUREG/CR-2858 Appendix B.

**Short-Term Dispersion Estimates
 Meteorological Episode: 2004-2013
 Revision 1**

**Table 2. Validation of PAVAN Installation
 Comparison of PAVAN Output from TVA Test Case #1 and NUREG Test Case #1 (NUREG/CR-2858 Appendix B)**

PAVAN Output		0-2 Hours		0-8 Hours		8-24 Hours		1-4 Days		4-30 Days		Annual Average	
Distance (meters)	Sector	TVA Result	NUREG Result	TVA Result	NUREG Result	TVA Result	NUREG Result	TVA Result	NUREG Result	TVA Result	NUREG Result	TVA Result	NUREG Result
805.	S	4.22e-4	4.22e-4	3.21e-4	3.21e-4	2.80e-4	2.80e-4	2.08e-4	2.08e-4	1.36e-4	1.36e-4	8.11e-5	8.11e-5
4989.	NNW	1.39e-4	1.39e-4	7.69e-5	7.69e-5	5.71e-5	5.71e-5	2.99e-5	2.99e-5	1.18e-5	1.18e-5	3.80e-6	3.80e-6
1127.	SSE	3.00e-4	3.00e-4	2.22e-4	2.22e-4	1.91e-4	1.91e-4	1.38e-4	1.38e-4	8.62e-5	8.62e-5	4.85e-5	4.85e-5
1931.	S	2.01e-4	2.01e-4	1.30e-4	1.30e-4	1.04e-4	1.04e-4	6.48e-5	6.48e-5	3.28e-5	3.28e-5	1.42e-5	1.42e-5
6437.	NNW	1.14e-4	1.14e-4	6.02e-5	6.02e-5	4.37e-5	4.37e-5	2.18e-5	2.18e-5	8.01e-6	8.01e-6	2.36e-6	2.36e-6
4345.	SSE	1.11e-4	1.11e-4	5.91e-5	5.91e-5	4.32e-5	4.32e-5	2.19e-5	2.19e-5	8.24e-6	8.24e-6	2.49e-6	2.49e-6
Site Limit X/Qs													
805.		1.98e-4	1.98e-4	1.71e-4	1.71e-4	1.59e-4	1.59e-4	1.35e-4	1.35e-4	1.07e-4	1.07e-4	8.11e-5	8.11e-5
1931.		7.44e-5	7.44e-5	5.66e-5	5.66e-5	4.94e-5	4.94e-5	3.67e-5	3.67e-5	2.40e-5	2.40e-5	1.42e-5	1.42e-5

PAVAN Results

RG 1.145 requires that the X/Q values at the EAB and LPZ be calculated based on both a directionally dependent methodology (maximum sector) and a directionally independent methodology (overall site limit) and that the most conservative (highest) values be chosen. Therefore, consistent with RG 1.145, the PAVAN model calculates the maximum sector X/Q by taking the X/Q value exceeded 0.5% of the time based on a cumulative probability distribution of X/Q values for each sector. Also in accordance with RG 1.145, the model calculates an overall site X/Q value by selecting the X/Q value that is exceeded 5 percent of the total time based on an overall cumulative probability distribution for all directions combined. The higher of the two values was then chosen to be the bounding X/Q value for each of the time periods analyzed. Tables 3-5 present the bounding X/Q values for SQN utilizing meteorological data from 2004-2013 at the EAB and LPZ, respectively.

Table 3. Exclusion Area Boundary (EAB) X/Q Values (sec/m³)

0.5th and 5% X/Q Values (sec/m³)				
EAB	Time Period	Direction-Dependent X/Q		Direction Independent X/Q
		<i>0.5% Maximum</i>	<i>Sector</i>	<i>5% Site Limit</i>
EAB-1 (556m)	0-2 Hours	8.82E-04	SSW	6.60E-04
EAB-2 (600m)	0-2 Hours	7.76E-04	SSW	5.81E-04
EAB-3 (509m)	0-2 Hours	1.02E-03	SSW	7.65E-04

Table 4. Low Population Zone (LPZ) X/Q Values (sec/m³)

0.5th and 5% X/Q Values (sec/m³)				
LPZ	Time Period	Direction-Dependent X/Q		Direction Independent X/Q
		<i>0.5% Maximum</i>	<i>Sector</i>	<i>5% Site Limit</i>
LPZ (4828m)	0-2 hours	8.78E-05	SSW	6.26E-05
LPZ (4828m)	0-8 Hours	4.45E-05	SSW	3.36E-05
LPZ (4828m)	8-24 Hours	3.17E-05	SSW	2.46E-05
LPZ (4828m)	1-4 Days	1.52E-05	SSW	1.25E-05
LPZ (4828m)	4-30 Days	5.26E-06	SSW	4.73E-06

Table 5. Bounding X/Q Values (sec/m³) at the EAB and LPZ

Bounding X/Q Values (sec/m³)					
Based on 2004-2013 Meteorology					
Location	0-2 Hours	0-8 Hours	8-24 Hours	1-4 Days	4-30 Days
EAB (509m)	1.02E-03	--	--	--	--
LPZ (4828m)	8.78E-05	4.45E-05	3.17E-05	1.52E-05	5.26E-06

**Short-Term Dispersion Estimates
Meteorological Episode: 2004-2013
Revision 1**

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