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Atmospheric Dispersion of Ammonia Accidentally Released from the 242-A Evaporator, Hanford Site, Richland, Washington

P. M. Daling
J. C. Lavender

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Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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EXECUTIVE SUMMARY

Two errors have been identified in the authorization basis for the 242-A Evaporator at the Hanford Site. These errors, which appear in the *242-A Evaporator/Crystallizer Final Safety Analysis Report* analysis of ammonia gas concentrations accidentally released from the 242-A Evaporator, are: 1) the vessel ventilation system flow rate used in the previous calculations is a factor of ten higher than the actual flow rate, and 2) the previous calculations did not account for the ammonia source term reduction that would occur via condensation of ammonia vapors, which will remove a large fraction of the ammonia from the exhaust gas stream. The purpose of this document is to correct these errors and recalculate the maximum ground-level concentrations of ammonia released to the environment as a result of potential errors in blending Evaporator feed. The errors offset each other somewhat, so it is unlikely that the 242-A Evaporator has operated outside its current authorization basis. However, the errors must be corrected and the results incorporated into a revision of the *242-A Evaporator/Crystallizer Safety Analysis Report*, WHC-SD-WM-SAR-023.

An EPA-approved atmospheric dispersion model, SCREEN3, was used to recalculate the maximum ground-level concentrations of ammonia that would be released from the 242-A Evaporator as a result of a feed-blending error. The results of the re-analysis of the 242-A Evaporator's ammonia release scenario are as follows. The onsite receptor 100 m away from the release point (242-A vessel vent stack) is projected to be exposed to a maximum ground-level concentration of ammonia of 8.3 ppm. The maximally-exposed offsite receptor, located at the nearest Hanford Site boundary 16 km away from the 242-A vessel vent stack, will be exposed to a maximum ground-level concentration of 0.11 ppm ammonia. Both concentrations are below the respective risk evaluation guidelines for exposures to ammonia or 25 ppm to the maximum onsite individual and 35 ppm to the maximum offsite individual.

The previous analysis calculated a peak concentration of 3.8 ppm ammonia at 2,900 m from the release point. The main differences between the results developed in this study and the previous analysis are:

- reduced ammonia emission rate (due to condensation of ammonia vapors)
- reduced stack exit velocity (due to the reduced vessel vent system flow rate)
- meteorological conditions (this analysis iterates until the worst-case wind-speed/stability class conditions are identified whereas the previous analysis considered one combination of wind speed and stability class)
- this analysis considered building downwash and wake effects whereas the previous analysis did not.

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1.0 INTRODUCTION AND BACKGROUND

A potential release of ammonia gas is an accident scenario analyzed in detail in WHC-SD-WM-SAR-023, *242-A Evaporator/Crystallizer Safety Analysis Report* (WMSH 1997), hereinafter referred to as the "SAR." Two errors were discovered in supporting documentation for the SAR, WHC-SD-WM-TI-494 Rev. 0, *Compilation of Calculations Used to Support 242-A Evaporator SAR* (WHC 1991) leading to a potential inadequacy in the 242-A Authorization Basis. The purpose of this document is to correct these errors and recalculate the concentrations of ammonia released to the environment at the receptor locations specified in the SAR.

The two errors identified in the SAR supporting document are:

- The volumetric flow rate of the Evaporator's vessel ventilation system was stated in the supporting document to be 6,400 ft³/min. The actual volumetric flow rate, as stated in the SAR, is 640 ft³/min. The result of this error is to understate by an order of magnitude the concentration of ammonia gas released from the 242-A Evaporator stack as a result of this accident scenario. This will understate the downwind concentrations of ammonia released, resulting in non-conservative ammonia concentrations at the onsite and offsite receptor locations.
- The accident analysis in the SAR states that "... all of the ammonia in the feed is converted to ammonia gas in the Evaporator." Under actual processing conditions, only about 1% of the ammonia entering the Evaporator is released out the stack, based on sampling data presented in WHC-SD-WM-PE-033, *242-A Evaporator/ Crystallizer FY 1987 Campaign 87-3 Post Run Document* (Winkler 1987). Unpublished data from a more recent Evaporator campaign indicated that approximately 5.5% of the ammonia in the feed was released through the vessel ventilation system stack to the environment. Consequently, it can be concluded that far less than 100% of the ammonia in the feed would be released to the environment. The fraction of ammonia in the feed that is released through the vessel ventilation system stack that was used in this analysis was assumed to be 10%, although a valid case can be made for an even smaller fraction.

Using these revised bases and maintaining the other parameters used in the accident analysis, revised downwind ammonia concentrations were calculated. Maximum ground-level concentrations are calculated at two maximally-exposed receptor locations: 100 m from the release point to the maximally-exposed onsite individual and 16 km from the release point to the maximally-exposed offsite individual. The SCREEN3 computer code, an EPA-approved atmospheric dispersion model, was used in the calculations. A description of SCREEN3 is provided Section in 2.2. Input parameters and their bases are discussed in Section 2.3. Results and conclusions from the analysis, including comparisons of the calculated onsite and offsite ammonia concentrations, are provided in Chapter 3.

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2.0 AMMONIA ACCIDENT SCENARIO ANALYSIS

This section describes the ammonia accident scenario analysis performed to correct the errors in the previous accident analysis. Included in this section are brief summaries of the ammonia release scenario, the computer software used to model the release and atmospheric dispersion of ammonia from the vessel ventilation system stack, and the input parameters used in the dispersion calculations.

2.1 AMMONIA ACCIDENT SCENARIO DESCRIPTION

This section describes the 242-A Evaporator's vessel ventilation system and summarizes the ammonia accident scenario analyzed in the SAR. The reader is referred to the Evaporator SAR for additional details on the vessel ventilation system as well as other Evaporator systems and processes.

The 242-A Evaporator is provided with a vessel ventilation system that filters and discharges noncondensable vapors, including ammonia, from the Evaporator's vacuum condenser system and condensate collection tank. The vessel ventilation system is illustrated in Figure 1. As shown, the system consists of the following major components:

- Deentrainment unit to remove liquids from the offgas stream
- Prefilter/demister for additional liquid removal from the offgas
- Electric heater to protect moisture accumulation on the HEPA filters
- Two high-efficiency particulate air (HEPA) filters in series
- Exhaust fan with a capacity of 20 m³/min (700 ft³/min) at 2.5 kPa (10-in. water gauge)
- Vessel ventilation system stack, designated Stack 296-A-22.

The vessel ventilation system is also equipped with various monitors and alarms, including pressure drop across the deentrainer, demister, and HEPA filters; inlet and outlet temperatures for the heater; and a stack-monitoring system, including an ammonia monitor.

The 242-A Evaporator SAR postulates that a higher than expected ammonia release occurs at the 242-A Evaporator due to errors in blending high-ammonia waste feed (neutralized cladding removal waste, or NCRW, was assumed in the analysis) with non-ammonia-bearing wastes. The blending error, which would occur in double-shell tank (DST) 241-AW-102, the Evaporator feed tank, was assumed not to be detected or corrected, and the contents of the feed tank are fed to the Evaporator, resulting in an elevated release of ammonia. Failure of routine sampling of the Evaporator feed and failure of the ammonia monitor in the vessel ventilation system stack was also assumed to occur, allowing the release to continue for several hours.

Figure 2.1. Schematic of 242-A Evaporator Vessel Ventilation System

2.2 ATMOSPHERIC DISPERSION MODEL DESCRIPTION

The SCREEN3 computer code (EPA 1995a) was used to calculate the air concentrations of ammonia released from the 242-A Evaporator stack at various distances. A Gaussian plume model that incorporates source-related factors and meteorological factors to estimate pollutant concentration from continuous sources is employed in SCREEN3. The pollutant, in this case ammonia, is assumed not to undergo any chemical reactions. No other removal processes, such as wet or dry deposition, are assumed to act on the plume during its transport from the source. The Gaussian model equations and the interactions of the source-related and meteorological factors are described in various documents [see, for example, Volume II of the Industrial Source Complex (ISC3) dispersion model user's guide (EPA 1995b)].

SCREEN3 can be used to model plume impacts from point sources, flare releases, and volume releases. For this analysis, only the point source model is used as ammonia would be released through an elevated stack at the 242-A Evaporator. SCREEN3 calculates the maximum ground-level concentrations of the released pollutant and the distance to the maximum concentrations. SCREEN3 incorporates the effects of building downwash on the maximum concentrations. SCREEN3 also incorporates the effects of buoyancy-induced dispersion. SCREEN3 is also capable of modeling complex terrains and receptor locations above ground level, although these latter two options were not used in this analysis.

SCREEN3 examines a range of atmospheric stability classes and wind speeds to identify the worst-case meteorological conditions. This results in a determination of the combination of wind speed and stability class that results in the maximum ground-level concentrations. No user-supplied or site-specific meteorological data are required to run SCREEN3.

2.3 INPUT DATA USED IN ATMOSPHERIC DISPERSION CALCULATIONS

This section presents the input parameters used to model the release of ammonia from the 242-A Evaporator stack. The input parameters and their bases are described below:

Emission Rate: The emission rate was calculated in the same manner as the previous calculations in WHC (1991) but was modified to account for the 90% reduction in ammonia emissions described in Section 1.0. According to the Evaporator SAR, the highest ammonia concentration expected in the aqueous feed to the Evaporator is 0.4 molar (M) or 6.8 g ammonia per liter (g/L). The maximum feed flow rate is 530 L/min (140 gal/min). Based on the discussion in Section 1.0, it is assumed that 90% of the ammonia is condensed out in the condenser and 10% of it is passed through to the vessel vent system. Thus, the emission rate of ammonia is:

$$\begin{aligned}
 \text{Emission Rate} &= (\text{Feed Flow Rate})(\text{Feed concentration})(1 - \text{Condensed Fraction}) \\
 &= (530 \text{ L/min}) * (6.8 \text{ g/L}) * (0.1) \\
 &= 360.4 \text{ g/min} * (\text{min}/60 \text{ sec}) \\
 &= 6.01 \text{ g/sec}
 \end{aligned}$$

The data supporting the 90% reduction in ammonia concentration via condensation are in Winkler (1987). As indicated in Section 1.0, a larger reduction due to condensation is supported by the data, but 90% is used here for conservatism.

242-A Evaporator Stack Parameters: The stack for the vessel vent system, designated stack 296-A-22, is 9.3 m above ground level and has an inside diameter of 0.2 m (8 in.). Both of these values were taken directly from the Evaporator SAR supporting calculations (WHC 1991).

Stack Exit Velocity: The volumetric flow rate out the vessel vent system stack used in this analysis is 18.1 m³/min (640 ft³/min), or 0.302 m³/sec. The stack exit velocity is obtained by dividing the volumetric flow rate by the cross-sectional area of the stack, as follows:

$$V_{Exit} = \frac{4VF}{\pi D_0^2}$$

where V_{Exit} = Linear exit velocity (m/sec)
 VF = Volumetric flow rate (0.302 m³/sec)
 D_0 = Stack diameter (0.2 m)

The resulting exit velocity is 9.61 m/sec. Note that when the volumetric flow rate used in WHC (1991) of 6400 ft³/min (3.02 m³/sec) is used, the resulting exit velocity is 96.1 m/sec.

Stack Gas Exit Temperature: The temperature of the gases released from the 242-A vessel vent stack is assumed to be 93°C (366K), consistent with the previous calculations (WHC 1991). The ambient air temperature was assumed to be 20°C (293K), the SCREEN3 code default ambient air temperature.

Building Dimensions: Building dimensions are required for SCREEN3 to model building downwash and wake effects. The building dimensions used here were taken from the Evaporator SAR, p. 5-6, and are as follows: building height - 19 m (62 ft) above grade; width - 23 m (75 ft); length - 33 m (108 ft).

Simple or Complex Terrain: SCREEN3's simple, flat terrain model was used here because the terrain surrounding the 242-A Evaporator is below the stack height. All receptors were assumed to be at ground level.

3.0 RESULTS AND CONCLUSIONS

This section presents the results of the SCREEN3 atmospheric dispersion calculations and any conclusions derived from the calculated maximum ground-level ammonia concentrations. A comparison of the present analysis with the previous results in the 242-A Evaporator SAR is also provided.

3.1 AMMONIA CONCENTRATIONS AT RECEPTOR LOCATIONS

The maximum ground-level concentrations of ammonia were calculated for two receptor locations. The maximally-exposed onsite receptor was assumed to be located 100 m from the release point and the maximally-exposed offsite receptor is located 16 km from the 242-A Evaporator (WMSH 1997). Wind direction is not relevant to these calculations as SCREEN3 automatically determines the wind speed and stability class that results in the maximum ground-level concentrations. The highest offsite concentration will be at the Hanford Site boundary nearest the 242-A Evaporator, or 16 km away. The output file created by SCREEN3 for these calculations is presented in Appendix A.

The maximum ground-level ammonia concentrations calculated by the SCREEN3 computer code are:

- **Onsite receptor location:** The maximally-exposed onsite receptor was assumed to be located 100 m away from the release point. The ammonia concentration at this location was calculated to be $5,894 \mu\text{g}/\text{m}^3$, or $5.894 \text{ mg}/\text{m}^3$. This was converted to units of parts per million (ppm) by volume using the following formula taken from EPA (1992):

$$\text{Concentration (ppm)} = \frac{\text{Concentration (mg/m}^3\text{)} * 24.04}{\text{Pollutant Molecular Weight (17 g/g-mole)}}$$

The resulting concentration was calculated to be 8.3 ppm at 100 m.

- **Offsite receptor location:** The maximally-exposed offsite receptor at 16 km away from the vessel vent stack would be exposed to a concentration of $78.25 \mu\text{g}/\text{m}^3$, or $0.07825 \text{ mg}/\text{m}^3$. Using the conversion formula shown above, this is equivalent to a concentration of 0.11 ppm.

3.2 COMPARISON WITH PREVIOUS RESULTS

Because a different computer code was used in this analysis than was used in the previous calculations (WHC 1991), an additional SCREEN3 run was made to determine

whether or not the choice of computer code would produce drastically different results. The SCREEN3 code was implemented with the same input parameters used in WHC (1991) to develop comparable results. The differences are highlighted below:

Parameter	SCREEN3 Record Case	SCREEN3 Comparison Case
Emission Rate, g/sec	6.01	60.1
Stack Exit Velocity, m/sec	9.61	96.1
Wind speed and stability class	SCREEN3 determines worst-case conditions	Pasquil F and 1 m/sec were the only conditions used
Building downwash considered?	YES	NO

All other parameters were the same, including stack height and stack inside diameter. In addition, the SCREEN3 comparison case was set to use only the wind speed and stability class that were used in the WHC (1991) calculations (Pasquil Stability Class F and 1 m/sec wind speed) rather than the SCREEN3 record case which was set to select the wind speed and stability class combination that resulted in the highest ground-level concentrations. Consequently, the results of the comparison case are comparable to the previous result; the model used to perform the calculations is the only significant difference. The SCREEN3 output file for this comparison case is presented in Appendix A.

As shown in Appendix A, the results of the comparison case run with SCREEN3 calculated a maximum ground-level concentration of $2986 \mu\text{g}/\text{m}^3$ (4.2 ppm) ammonia at a downwind distance of a little over 2 km. The results of the previous analysis indicated that the maximum concentration of 3.8 ppm ammonia occurred at about 2.9 km away from the release point. At 2.9 km away from the stack, the location of maximum concentration determined in WHC (1993), SCREEN3 calculated a ground-level concentration of about 3.9 ppm. This is close to the 3.8 ppm concentration of 2.9 km calculated in WHC (1993). Therefore, it was concluded that the SCREEN3-generated maximum ground-level concentrations results are slightly more conservative than concentrations calculated in WHC (1993). The calculated concentrations were approximately the same when comparing the calculated concentrations at identical distances.

3.3 COMPARISON TO RISK EVALUATION GUIDELINES

Onsite and offsite risk evaluation guidelines for exposures to hazardous chemicals are specified in the current revision of the Evaporator SAR as follows for anticipated events (i.e., events with frequencies greater than one per hundred years):

- **Onsite receptor:** The risk evaluation guideline for an onsite receptor exposed to an anticipated event is the Emergency Response Planning Guideline - 1 (ERPG-1) value specified by the American Industrial Hygiene Association (AIHA). The ERPG-1 value for ammonia is 25 ppm.¹ The calculated concentration at 100 m from the release point was 8.3 ppm. This is well below the risk evaluation guideline for anticipated events.
- **Offsite receptor:** The offsite risk evaluation guideline for anticipated releases of chemicals is represented by the Permissible Exposure Level - Time-weighted Average (PEL-TWA) values. The PEL-TWA for ammonia is 35 ppm. Alternatively, the Threshold Limit Value - Time-weighted Average (TLV-TWA) published by the American Council of Government and Industrial Hygienists (ACGIH) is 25 ppm for ammonia. (Both offsite receptor values were taken from NIOSH 1990.) The calculated maximum offsite ammonia concentration was about 0.1 ppm, well below both potential offsite risk evaluation guidelines for anticipated events involving toxic chemical releases.

Overall, it was concluded that the ammonia release scenario is within risk evaluation guidelines for both onsite and offsite receptors.

¹ AIHA and Hanford-developed ERPG values are available on the Hanford Local Area Network in Hanford Information under Hanford Emergency Response Planning Guide for Chemicals.

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APPENDIX A
SCREEN3 OUTPUT FILES

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APPENDIX A

SCREEN3 OUTPUT FILES

The following SCREEN3 output file is for the ammonia release to be used to support the revision to ammonia accident analysis for the 242-A Evaporator safety analysis.

11/05/97
13:32:01

*** SCREEN3 MODEL RUN ***
*** VERSION DATED 96043 ***

Record Case - Ammonia Release from 242-A Evaporator

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	POINT
EMISSION RATE (G/S)	=	6.01000
STACK HEIGHT (M)	=	9.3000
STK INSIDE DIAM (M)	=	.2000
STK EXIT VELOCITY (M/S)	=	9.6100
STK GAS EXIT TEMP (K)	=	366.0000
AMBIENT AIR TEMP (K)	=	293.0000
RECEPTOR HEIGHT (M)	=	.0000
URBAN/RURAL OPTION	=	RURAL
BUILDING HEIGHT (M)	=	19.0000
MIN HORIZ BLDG DIM (M)	=	23.0000
MAX HORIZ BLDG DIM (M)	=	33.0000

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

BUOY. FLUX = .188 M⁴/S³; MOM. FLUX = .739 M⁴/S².

*** FULL METEOROLOGY ***

*** SCREEN AUTOMATED DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
100.	5894.	3	1.0	1.0	320.0	9.37	16.96	16.18	SS
200.	3172.	6	1.0	1.0	10000.0	10.13	23.92	22.86	SS
300.	2745.	6	1.0	1.0	10000.0	10.13	27.10	23.41	SS
400.	2414.	6	1.0	1.0	10000.0	10.13	30.25	23.96	SS
500.	2149.	6	1.0	1.0	10000.0	10.13	33.36	24.50	SS
600.	1933.	6	1.0	1.0	10000.0	10.13	36.45	25.02	SS
700.	1753.	6	1.0	1.0	10000.0	10.13	39.50	25.54	SS
800.	1601.	6	1.0	1.0	10000.0	10.13	42.54	26.05	SS
900.	1471.	6	1.0	1.0	10000.0	10.13	45.54	26.55	SS
1000.	1384.	6	1.0	1.0	10000.0	10.13	48.53	26.48	SS
1100.	1283.	6	1.0	1.0	10000.0	10.13	51.50	26.97	SS
1200.	1198.	6	1.0	1.0	10000.0	10.13	54.45	27.39	SS
1300.	1122.	6	1.0	1.0	10000.0	10.13	57.38	27.79	SS
1400.	1055.	6	1.0	1.0	10000.0	10.13	60.29	28.20	SS
1500.	994.5	6	1.0	1.0	10000.0	10.13	63.19	28.59	SS
1600.	939.9	6	1.0	1.0	10000.0	10.13	66.07	28.98	SS
1700.	890.5	6	1.0	1.0	10000.0	10.13	68.94	29.36	SS
1800.	845.5	6	1.0	1.0	10000.0	10.13	71.80	29.74	SS
1900.	804.4	6	1.0	1.0	10000.0	10.13	74.64	30.11	SS
2000.	766.8	6	1.0	1.0	10000.0	10.13	77.47	30.47	SS
2100.	732.1	6	1.0	1.0	10000.0	10.13	80.29	30.83	SS
2200.	700.2	6	1.0	1.0	10000.0	10.13	83.10	31.19	SS
2300.	670.6	6	1.0	1.0	10000.0	10.13	85.90	31.54	SS
2400.	643.2	6	1.0	1.0	10000.0	10.13	88.68	31.89	SS
2500.	617.7	6	1.0	1.0	10000.0	10.13	91.46	32.23	SS
2600.	593.9	6	1.0	1.0	10000.0	10.13	94.22	32.57	SS
2700.	571.8	6	1.0	1.0	10000.0	10.13	96.98	32.90	SS
2800.	551.0	6	1.0	1.0	10000.0	10.13	99.73	33.23	SS
2900.	531.5	6	1.0	1.0	10000.0	10.13	102.46	33.56	SS
3000.	513.2	6	1.0	1.0	10000.0	10.13	105.19	33.89	SS
3500.	436.4	6	1.0	1.0	10000.0	10.13	118.72	35.45	SS
4000.	377.7	6	1.0	1.0	10000.0	10.13	132.06	36.94	SS
4500.	331.6	6	1.0	1.0	10000.0	10.13	145.23	38.37	SS
5000.	294.5	6	1.0	1.0	10000.0	10.13	158.26	39.73	SS
5500.	268.9	6	1.0	1.0	10000.0	10.13	171.15	40.28	SS
6000.	243.7	6	1.0	1.0	10000.0	10.13	183.92	41.43	SS
6500.	222.4	6	1.0	1.0	10000.0	10.13	196.57	42.54	SS
7000.	204.2	6	1.0	1.0	10000.0	10.13	209.12	43.60	SS
7500.	188.5	6	1.0	1.0	10000.0	10.13	221.57	44.64	SS
8000.	174.8	6	1.0	1.0	10000.0	10.13	233.93	45.64	SS
8500.	162.8	6	1.0	1.0	10000.0	10.13	246.20	46.61	SS

9000.	152.2	6	1.0	1.0	10000.0	10.13	258.39	47.55	SS
9500.	142.8	6	1.0	1.0	10000.0	10.13	270.50	48.47	SS
10000.	134.3	6	1.0	1.0	10000.0	10.13	282.53	49.36	SS
15000.	84.33	6	1.0	1.0	10000.0	10.13	399.49	55.86	SS
20000.	60.36	6	1.0	1.0	10000.0	10.13	511.61	61.10	SS
25000.	46.50	6	1.0	1.0	10000.0	10.13	620.10	65.55	SS
30000.	37.77	6	1.0	1.0	10000.0	10.13	725.68	69.05	SS
40000.	27.30	6	1.0	1.0	10000.0	10.13	929.91	74.66	SS
50000.	21.22	6	1.0	1.0	10000.0	10.13	1126.79	79.34	SS

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 100. M:

100.	5894.	3	1.0	1.0	320.0	9.37	16.96	16.18	SS
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SEE NOTES 1 AND 2

DWASH= MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, $X < 3 \times LB$

 *** SCREEN DISCRETE DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
16000.	78.25	6	1.0	1.0	10000.0	10.13	422.25	56.99	SS

SEE NOTES 1 AND 2

DWASH= MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, $X < 3 \times LB$

*** REGULATORY (Default) ***
 PERFORMING CAVITY CALCULATIONS
 WITH ORIGINAL SCREEN CAVITY MODEL
 (BRODE, 1988)

*** CAVITY CALCULATION - 1 ***

CONC (UG/M**3) = 6390.
 CRIT WS @10M (M/S) = 1.00
 CRIT WS @ HS (M/S) = 1.00
 DILUTION WS (M/S) = 1.00
 CAVITY HT (M) = 25.30
 CAVITY LENGTH (M) = 39.28
 ALONGWIND DIM (M) = 23.00

*** CAVITY CALCULATION - 2 ***

CONC (UG/M**3) = 9169.
 CRIT WS @10M (M/S) = 1.00
 CRIT WS @ HS (M/S) = 1.00
 DILUTION WS (M/S) = 1.00
 CAVITY HT (M) = 22.18
 CAVITY LENGTH (M) = 22.03
 ALONGWIND DIM (M) = 33.00

END OF CAVITY CALCULATIONS

*** SUMMARY OF SCREEN MODEL RESULTS ***

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	5894.	100.	0.
BLDG. CAVITY-1	6390.	39.	-- (DIST = CAVITY LENGTH)
BLDG. CAVITY-2	9169.	22.	-- (DIST = CAVITY LENGTH)

SEE NOTE 3

** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **

NOTES

- 1) Results of analysis are in bold type.
- 2) Pasquil Stability Class designations are as follows, 1 = Class A, 2 = Class B, ..., 6 = Class F
- 3) Building cavity concentrations are not applicable to this analysis. Nearest onsite individual is assumed to be located 100 m away from release point and is not located within building cavity where building downwash phenomena tends to increase pollutant concentrations.

 The following SCREEN3 output file is for the comparison to the previous
 results that were described in WHC (1993).

11/06/97
 08:14:58

*** SCREEN3 MODEL RUN ***
 *** VERSION DATED 96043 ***

Run to Duplicate Previous Analysis

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	POINT
EMISSION RATE (G/S)	=	60.1000
STACK HEIGHT (M)	=	9.3000
STK INSIDE DIAM (M)	=	.2000
STK EXIT VELOCITY (M/S)	=	96.1000
STK GAS EXIT TEMP (K)	=	366.0000
AMBIENT AIR TEMP (K)	=	293.0000
RECEPTOR HEIGHT (M)	=	.0000
URBAN/RURAL OPTION	=	RURAL
BUILDING HEIGHT (M)	=	.0000
MIN HORIZ BLDG DIM (M)	=	.0000
MAX HORIZ BLDG DIM (M)	=	.0000

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
 THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

BUOY. FLUX = 1.880 M**4/S**3; MOM. FLUX = 73.932 M**4/S**2.

*** STABILITY CLASS 6 ONLY ***
 *** ANEMOMETER HEIGHT WIND SPEED OF 1.00 M/S ONLY ***

 *** SCREEN AUTOMATED DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
100.	12.99	6	1.0	1.0	10000.0	39.74	9.60	9.00	NO
200.	33.22	6	1.0	1.0	10000.0	39.74	11.63	9.61	NO
300.	82.67	6	1.0	1.0	10000.0	39.74	14.21	10.36	NO
400.	184.1	6	1.0	1.0	10000.0	39.74	17.03	11.19	NO
500.	356.8	6	1.0	1.0	10000.0	39.74	19.96	12.09	NO
600.	606.4	6	1.0	1.0	10000.0	39.74	22.95	13.02	NO
700.	921.9	6	1.0	1.0	10000.0	39.74	25.96	13.97	NO
800.	1214.	6	1.0	1.0	10000.0	39.74	28.97	14.80	NO
900.	1509.	6	1.0	1.0	10000.0	39.74	31.98	15.63	NO
1000.	1792.	6	1.0	1.0	10000.0	39.74	34.98	16.44	NO
1100.	2022.	6	1.0	1.0	10000.0	39.74	37.97	17.18	NO
1200.	2226.	6	1.0	1.0	10000.0	39.74	40.95	17.91	NO
1300.	2402.	6	1.0	1.0	10000.0	39.74	43.91	18.63	NO
1400.	2551.	6	1.0	1.0	10000.0	39.74	46.86	19.33	NO
1500.	2675.	6	1.0	1.0	10000.0	39.74	49.80	20.02	NO
1600.	2776.	6	1.0	1.0	10000.0	39.74	52.72	20.70	NO
1700.	2855.	6	1.0	1.0	10000.0	39.74	55.62	21.37	NO
1800.	2914.	6	1.0	1.0	10000.0	39.74	58.52	22.02	NO
1900.	2958.	6	1.0	1.0	10000.0	39.74	61.40	22.67	NO
2000.	2986.	6	1.0	1.0	10000.0	39.74	64.27	23.31	NO
2100.	2983.	6	1.0	1.0	10000.0	39.74	67.12	23.85	NO
2200.	2972.	6	1.0	1.0	10000.0	39.74	69.97	24.38	NO
2300.	2955.	6	1.0	1.0	10000.0	39.74	72.80	24.91	NO
2400.	2933.	6	1.0	1.0	10000.0	39.74	75.62	25.42	NO
2500.	2906.	6	1.0	1.0	10000.0	39.74	78.43	25.93	NO
2600.	2877.	6	1.0	1.0	10000.0	39.74	81.23	26.42	NO
2700.	2844.	6	1.0	1.0	10000.0	39.74	84.02	26.91	NO
2800.	2810.	6	1.0	1.0	10000.0	39.74	86.80	27.40	NO
2900.	2773.	6	1.0	1.0	10000.0	39.74	89.57	27.87	NO
3000.	2736.	6	1.0	1.0	10000.0	39.74	92.33	28.34	NO
3500.	2518.	6	1.0	1.0	10000.0	39.74	106.01	30.26	NO
4000.	2316.	6	1.0	1.0	10000.0	39.74	119.49	32.04	NO
4500.	2133.	6	1.0	1.0	10000.0	39.74	132.79	33.71	NO
5000.	1971.	6	1.0	1.0	10000.0	39.74	145.93	35.30	NO
5500.	1826.	6	1.0	1.0	10000.0	39.74	158.93	36.80	NO
6000.	1697.	6	1.0	1.0	10000.0	39.74	171.80	38.24	NO
6500.	1582.	6	1.0	1.0	10000.0	39.74	184.55	39.61	NO
7000.	1479.	6	1.0	1.0	10000.0	39.74	197.18	40.94	NO
7500.	1388.	6	1.0	1.0	10000.0	39.74	209.72	42.07	NO

8000.	1306.	6	1.0	1.0	10000.0	39.74	222.16	43.17	NO
8500.	1232.	6	1.0	1.0	10000.0	39.74	234.50	44.22	NO
9000.	1165.	6	1.0	1.0	10000.0	39.74	246.76	45.24	NO
9500.	1104.	6	1.0	1.0	10000.0	39.74	258.94	46.23	NO
10000.	1049.	6	1.0	1.0	10000.0	39.74	271.04	47.19	NO
15000.	686.2	6	1.0	1.0	10000.0	39.74	388.52	55.57	NO
20000.	506.7	6	1.0	1.0	10000.0	39.74	501.02	60.92	NO
25000.	398.7	6	1.0	1.0	10000.0	39.74	609.81	65.44	NO
30000.	327.0	6	1.0	1.0	10000.0	39.74	715.64	69.38	NO
40000.	240.9	6	1.0	1.0	10000.0	39.74	920.26	75.00	NO
50000.	189.7	6	1.0	1.0	10000.0	39.74	1117.46	79.67	NO

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 100. M:

2006.	2986.	6	1.0	1.0	10000.0	39.74	64.41	23.34	NO
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SEE NOTES 1 AND 2

DWASH= MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
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 *** SCREEN DISCRETE DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
2900.	2773.	6	1.0	1.0	10000.0	39.74	89.57	27.87	NO

SEE NOTES 1 AND 2

DWASH= MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, $X < 3 \cdot LB$

 *** SUMMARY OF SCREEN MODEL RESULTS ***

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	2986.	2006.	0.

 ** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **

NOTES

- 1) Results of analysis are in **bold type**.
- 2) Pasquill Stability Class designations are as follows, 1 = Class A, 2 = Class B, ..., 6 = Class F

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