ATTACHMENT 19, CALCULATION COVER SHEET

INITIATION (Control Doc Type - DCALC)

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DCALC No.: CA04542 Revision No.: 0

Vendor Calculation (Check one): ☐ Yes ☒ No

ESP ES199801040 Supp No.: 0 Rev. No.: 0

Responsible Group: NEG

Responsible Engineer: Gerard E. Gryczkowski

CALCULATION

ENGINEERING DISCIPLINE:

☐ Civil
☐ Electrical
☐ Life Cycle Mngmt
☐ Other:
☐ Instr & Controls
☐ Mechanical
☐ Reliability Engrg
☒ Nuc Engrg
☐ Diesel Gen Project
☐ Nuc Fuel Mngmt

Title: 375 GAL 35% HYDRAZINE
CONTROL ROOM CHEMICAL HABITABILITY

Unit ☐ UNIT 1 ☐ UNIT 2 ☒ COMMON

Proprietary or Safeguards Calculation ☐ YES ☒ NO

Comments: NA

Vendor Calc No.: NA REVISION NO.: NA

Vendor Name: NA

Safety Class (Check one): ☒ SR ☐ AQ ☐ NSR

There are assumptions that require Verification during walkdown: AIT # NA

This calculation **SUPERSEDES**: CA02241

REVIEW AND APPROVAL:

Responsible Engineer: Gerard E. Gryczkowski / G E Gryczkowski Date: 7/22/98

Independent Reviewer: I M Sommerville / I M Sommerville Date: 8/20/98

Approval: J. A. Mihalcik / J A Mihalcik Date: 30 Sept 1998

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5. PURPOSE

10CFR50 App.A GDC.19 (Ref.1) requires that a control room be provided, from which actions can be taken to operate the nuclear power plant safely under normal conditions and to maintain it in a safe condition under accident conditions. Release of hazardous chemicals can potentially result in the control room becoming uninhabitable. Thus the NRC requires each utility to assess the habitability of the control room during and after a postulated external release of hazardous chemicals based on the chemical toxicity limit, vaporization rate, and the relevant atmospheric dispersion coefficients (Ref.2). The explosion and flammability hazard of these chemicals must also be addressed (Ref.2).

Ecolochem, Inc. will use 35% hydrazine solution in the water treatment process. This solution will be stored in 375 gal tote bins at the tank farm, warehouse, and north service building (Att.F). The chemical habitability of the control room after a chemical release involving hydrazine was determined based on in-house dispersion calculations and toxicity determinations for the current control room configuration with the inleakage points at the control room inlet and exhaust dampers and for the modified control room configuration with the inleakage points at the west road inlet plenum (Refs.3-4). Results indicate that this solution can be stored in a 35% solution at the tank farm, warehouse, and north service building without constituting a toxicological or fire hazard to the control room following a worst case accident for both the current and modified control room configurations.

The results of the toxicity calculations for a 35% hydrazine solution are as follows:

		Peak Concentration (ppm)		
		Tank Farm	Warehouse	NSB
Current Configuratio	No Recirculation	0.88	0.25	2.80
	With Recirculation	0.88	0.25	2.80
Modified Configuration	With Recirculation	0.57	0.29	0.84
Toxicity Limit (IDLH)		80	80	80

Note that under the current and modified configurations, the peak control room concentration under worst case conditions is less than the IDLH toxicity limit, the maximum level from which one could escape within 30 minutes without any impairing symptoms or irreversible health effects.

The current calculation incorporates many assumptions which make these results conservative. (1) A maximum concentration limit (IDLH) was utilized that could be tolerated for 30 minutes without physical incapacitation of an average human. The regulatory requirements of Ref.2 dictate a maximum concentration limit that could be tolerated for 2 minutes without physical incapacitation of an average human. IDLH denotes Immediately Dangerous to Life and Health and is defined as the maximum level from which one could escape within 30 minutes without any impairing symptoms or irreversible health effects (Ref.5). (2) For the current configuration the maximum control room intake flowrate of 8300 cfm is utilized. This value is twice the normal operating value (Refs.6-8). (3) The control room volume conservatively neglects dead spaces in the control room ceiling and the volume of room A512. (4) The most conservative methodology is utilized: turbulent evaporation.

Hydrazine will not pose a flammability or explosion hazard in the control room, since the peak concentration is a small fraction of the lower explosion limit.

6. INPUT DATA

The following input data is incorporated into this work:

(01) Chemical data for hydrochloric acid:

CAS number	302-01-2	Refs.5,10
Chemical formula	N_2H_4	Refs.5,10
Toxicity Limit IDLH (ppm)	80.	Ref.5
Odor threshold (ppm)	3.	Ref.5
Volume fraction	0.35	Att.F
Volume (gal)	375	Att.F
Specific gravity (gm/cc)	1.008	Ref.5
Vapor pressure (mm Hg) VP	14.4@25°C	Ref.10
Boiling point (Degrees C) TB	113.5	Refs.5,10
Molecular weight (gm/mole) MB	32.05	Refs.5,10
Flash Point (Degrees C)	37.8	Refs.5,10
Lower explosion limit (Vol%)	2.9	Ref.10

(02) Physical properties of air per Refs.13,14:

Molecular weight (gm/mole) MA	28.97
Characteristic length in air (Angstroms) SIGA	3.711
Molecular energy of attraction/Boltzmann constant (K) E/KA	78.6
Mass density of air (gm/cc) RHOA	1.204E-03
Viscosity of Air (gm/cm-sec) MU	1.83E-04
Universal Gas Constant (torr-cm3/gmole-K) R	6.24E+04

(03) The updated control room volume of 234157 ft^3 was extracted from Ref.18.

(04) Control room damper inflow for the current configuration is extracted from Refs. 7-8 and is defined as 8300 cfm or twice the maximum flowrate.

(05) Control room inleakage for the modified configuration is extracted from Refs. 3-4 and is defined as 3000 cfm.

(06) The Tank Farm/Warehouse/North Service Building (NSB)-Control Room ARCON96 X/Q inputs were derived as follows (Att.B):

(a) Number of meteorological data files:	3	Refs.B2,B10
(b) Meteorological data file names:	CC1991.MET	Refs.B2,B10
	CC1992.MET	Refs.B2,B10
	CC1993.MET	Refs.B2,B10
(c) Height of lower wind instrument (m):	10.	Ref.B3
(d) Height of upper wind instrument (m):	60.	Ref.B3
(e) Wind speed units type (1=m/s, 2=mph, 3=knots):	1	Refs.B2,B10
(f) Release type (1=ground, 2=vent, 3=elevated):	1	

(g) Release height (m): 0.

(h) Building area (m^2): 1155. Att.G

The cross sectional area calculations are analyzed in Att.G. The calculation of containment cross sectional area yields 12435.63 ft^2 above the rooftop level of 91'6". The auxiliary building cross sectional area can be calculated to be 1938.93 ft^2. For a west-to-east wind direction, the total cross-sectional area of the auxiliary building and the two containments is 26810 ft^2. For an east-to-west wind direction, the total cross sectional area of the turbine building is 27167 ft^2. For a north-to-south and south-to-north wind direction, the total cross sectional area of the containment and the turbine building is 21016 ft^2. The cross-sectional area of a single containment of 12435.63 ft^2 or 1155 m^2 will conservatively be used.

(i) Effluent vertical velocity (m/s): 0

(j) Stack or vent flow (m^3/s): 0

(k) Stack or vent radius (m): 6.72

r = SQRT(A/π)
= SQRT[(375gal)*(3785.422cc/gal)/(1.cm)/π*(1.E-4m /cm^2)]
= 6.72 m

(l) Direction to source (deg):
333 Tank Farm Refs.B12,B14
174 Warehouse Refs.B12,B14
059 NSB Refs.B12,B14

(m) Source window (deg): 90 Refs.B13-B14

(n) Distance from source to receptor (m):
135 Tank Farm Refs.B12,B14
300 Warehouse Refs.B12,B14
067 NSB Refs.B12,B14

(o) Intake height (m): 15.62

91.5' + 4.75' - 45' = 51.25' = 15.62 m

where 91.5' is the height of the Auxiliary Building roof (Ref.B6), 4.75' is the control room exhaust height (Ref.B13), and 45' is ground level (Ref.B8).

(p) Grade elevation difference (m): 0 Ref.B1

(q) Primary output file name:
CHTFCR.OUT Tank Farm
CHWHCR.OUT Warehouse
CHNSBCR.OUT NSB

(r) JFT file name:
CHTFCR.JFD Tank Farm
CHWHCR.JFD Warehouse
CHNSBCR.JFD NSB

(s) Surface roughness length (m): 0.1 Ref.B1

(t) Minimum wind speed (m/s): 0.5 Ref.B1

(u) Sector averaging constant: 4 Ref.B1

(v) Hours in average: 1 2 4 8 12 24 96 168 360 720 Ref.B1

(w) Minimum number of hours: 1 2 4 8 11 22 87 152 324 648 Ref.B1

(x) Horizontal diffusion coefficient (m): 3.12
σ_y=r/2.15=6.72/2.15=3.12 m (Ref.B1)

(y) Vertical diffusion coefficient (m) 0.

(z) Flag for expanded output: n Ref.B1

(07) Atmospheric dispersion coefficients from the Tank Farm/Warehouse/NSB to the Control Room:

	Tank Farm	Warehouse	NSB
0- 2 hrs	3.33E-04 sec/m^3	9.17E-5 sec/m^3	1.06E-3 sec/m^3
2- 8 hrs	2.84E-04 sec/m^3	7.74E-5 sec/m^3	8.34E-4 sec/m^3
8- 24 hrs	1.26E-04 sec/m^3	3.20E-5 sec/m^3	3.71E-4 sec/m^3
24- 96 hrs	8.55E-05 sec/m^3	2.25E-5 sec/m^3	2.51E-4 sec/m^3
96-720 hrs	7.22E-05 sec/m^3	1.88E-5 sec/m^3	1.80E-4 sec/m^3

(Attachment B, Refs.B1, B10, B15)

(08) The Tank Farm/Warehouse/NSB-West Road Inlet ARCON96 X/Q inputs were derived as follows (Att.C):

(a) Number of meteorological data files: 3 Refs.B2,B10

(b) Meteorological data file names:
CC1991.MET Refs.B2,B10
CC1992.MET Refs.B2,B10
CC1993.MET Refs.B2,B10

(c) Height of lower wind instrument (m): 10. Ref.B3

(d) Height of upper wind instrument (m): 60. Ref.B3

(e) Wind speed units type (1=m/s, 2=mph, 3=knots): 1 Refs.B2,B10

(f) Release type (1=ground, 2=vent, 3=elevated): 1

(g) Release height (m): 0.

(h) Building area (m^2): 1155. Att.G

The cross sectional area calculations are analyzed in Att.G. The calculation of containment cross sectional area yields 12435.63 ft^2 above the rooftop level of 91'6". The auxiliary building cross sectional area can be calculated to be 1938.93 ft^2. For a west-to-east wind direction, the total cross-sectional area of the auxiliary building and the two containments is 26810 ft^2. For an east-to-west wind direction, the total cross sectional area of the turbine building is 27167 ft^2. For a north-to-south and south-to-north wind direction, the total cross sectional area of the containment and the turbine building is 21016 ft^2. The cross-sectional area of a single containment of 12435.63 ft^2 or 1155 m^2 will conservatively be used.

(i) Effluent vertical velocity (m/s): 0

(j) Stack or vent flow (m^3/s):	0	
(k) Stack or vent radius (m):	6.72	

$r = SQRT(A/\pi)$
$= SQRT[(375gal)*(3785.422cc/gal)/(1.cm)/\pi*(1.E\text{-}4m^2/cm^2)]$
$= 6.72$ m

(l) Direction to source (deg):	354 Tank Farm 162 Warehouse 050 NSB	Refs.B12,B14 Refs.B12,B14 Refs.B12.B14
(m) Source window (deg):	90	Refs.B13-B14
(n) Distance from source to receptor (m):	172 Tank Farm 262 Warehouse 135 NSB	Refs.B12,B14 Refs.B12,B14 Refs.B12,B14
(o) Intake height (m):	9.14	

The Auxiliary Building roof above the control room and above A512 will be sealed tight. Most control room inleakage can then be assumed to originate at the Auxiliary Building inlet plenum on the west road side (ES199702144). Per Ref.B11, the inlet plenum is 54'x10' with a bottom elevation of 70'. Thus the intake height is 75'-45'=30'=9.14 m

(p) Grade elevation difference (m):	0	Ref.B1
(q) Primary output file name:	CHTFWR.OUT CHWHWR.OUT CHNSBWR.OUT	Tank Farm Warehouse NSB
(r) JFT file name:	CHTFWR.JFD CHWHWR.JFD CHNSBWR.JFD	Tank Farm Warehouse NSB
(s) Surface roughness length (m):	0.1	Ref.B1
(t) Minimum wind speed (m/s):	0.5	Ref.B1
(u) Sector averaging constant:	4	Ref.B1
(v) Hours in average:	1 2 4 8 12 24 96 168 360 720	Ref.B1
(w) Minimum number of hours:	1 2 4 8 11 22 87 152 324 648	Ref.B1
(x) Horizontal diffusion coefficient (m):	3.12	

$\sigma_y=r/2.15=6.72/2.15=3.12$ m (Ref.B1)

(y) Vertical diffusion coefficient (m)	0.	
(z) Flag for expanded output:	n	Ref.B1

(09) Atmospheric dispersion coefficients from the Tank Farm/Warehouse/NSB to the West Road Inlet:

	Tank Farm	Warehouse	NSB
0- 2 hrs	2.15E-04 sec/m^3	1.10E-4 sec/m^3	3.18E-4 sec/m^3
2- 8 hrs	1.85E-04 sec/m^3	8.73E-5 sec/m^3	2.60E-4 sec/m^3
8- 24 hrs	8.55E-05 sec/m^3	3.22E-5 sec/m^3	1.22E-4 sec/m^3
24- 96 hrs	6.18E-05 sec/m^3	2.25E-5 sec/m^3	8.31E-5 sec/m^3
96-720 hrs	4.91E-05 sec/m^3	1.93E-5 sec/m^3	5.94E-5 sec/m^3

(Attachment C, Refs.B1, B10, B15)

7. TECHNICAL ASSUMPTIONS

The following technical assumptions were utilized in this work:

(01) Per Attachment F, a 35% Hydrazine Solution is stored in a tote bin of 375 gals capacity in the tank farm, warehouse, or north service building.

(02) Per Ref.15 in a postulated accident, it is assumed that the entire container of the toxic substance ruptures.

(03) An average ambient atmospheric temperature of 30°C and pressure of 760 torr will be used in this calculation. Variation in these parameters shows insignificant impact on the results (Ref.16). TA=30 PA=1

(04) The chemical spill will be assumed to spread in a circular shape with the maximum radius determined by a spill thickness of 1 cm per Ref.15.

(05) Based on the characteristics of the chemicals, the following release mechanisms will be assumed: For the hydrazine solution, the turbulent mass transfer is the worst of three methodologies: diffusion in still air, laminar mass transfer, and turbulent mass transfer.

(06) For laminar and turbulent mass flow, a wind speed of one meter/sec is assumed. This is consistent with the wind tunnel methodology and the CCNPP data of Ref.B3. Note that per Ref.17 (p.265), a flow with Reynold's Number less than 5E+05 is laminar.

(07) The vapor pressure of the spilled material will be adjusted to the ambient conditions via the ideal gas law:

$$VP(@T_a) = VP(@T_{vp}) * T_a / T_{vp}$$

8. REFERENCES

(01) "Control Room", 10CFR50, Appendix A, General Design Criterion 19.

(02) "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release", Regulatory Guide 1.78, 6/74.

(03) "Response to RAI: Accident Dose Analysis and Control Room Habitability Analysis for the MHA, FHA, and CEAEE", NRC-98-044.

(04) "Response to RAI: Control Room Habitability Analyses and MSLB Analyses", NRC-98-018.

(05) "Hazardous Chemicals Data Book", Second Edition, Edited by G.Weiss, Noyes Data Corporation.

(06) "Offsite and Control Room Doses Following a LOCA", Bechtel Calculation M-89-33 Rev.3, 7/9/91.

(07) "Fan Performance Curve", BGE DWG 12782-35, Rev.0.

(08) "Control Room Temperature During Normal and Emergency Recirculation Modes of Operation", Bechtel Calculation M-91-24, 11/9/92.

(09) "SAX's Dangerous Properties of Industrial Materials", Ninth Edition, Richard J. Lewis Sr.

(10) MSDS for Hydrazine, Attachment A.

(11) "The Merck Index", Eleventh Edition, 1989.

(12) "CRC Handbook of Physics and Chemistry", 66th Edition, 1985-1986.

(13) "Handbook of Chemical Property Estimation Methods, Environmental Behavior of Organic Compounds", W.Lyman, W.Reehl, and D.Rosenblatt, McGraw Hill 1982.

(14) "Flow of Fluids through Valves, Fittings, and Pipe", Crane Technical Paper No.410, 1988.

(15) "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release", NUREG-0570, 6/79.

(16) "CCNPP Control Room Habitability Evaluation Due to a Postulated Spill of Ethanolamine", Bechtel Calculation M-94-16 Rev.0, 11/10/94.

(17) "Heat Transfer", Seventh Edition, J.P.Holman.

(18) "Modeling of the Control Room/Cable Spreading Room HVAC System Using GOTHIC Software", CA02725, 1/8/97.

(B1) "Atmospheric Relative Concentrations in Building Wakes", NUREG/CR-6331 Rev.1, 5/97.

(B2) CCMAIL from Mark Abrams at PLG to G.E.Gryczkowski, 3/5/97.

(B3) "Wind Flows and Dispersion Conditions at Calvert Cliffs", Maria Gavrilas and Melissa Wieland, BG&E-EP1, 9/85.

(B4) "Atmospheric Dispersion Coefficient Calculations from the MSG and ADV to the Control Room", CA03533, 1/17/97.

(B5) "Auxiliary Building and Containment Structures Exterior Elevations East & West", BGE Drawing 62-047-E, Rev.6

(B6) "Auxiliary Building Roof Plan", BGE Drawing 62-043-E, Rev.12.

(B7) "Containment Liner Plan, Elevation & Penetrations", BGE Drawing 61-740-E, Rev.19.

(B8) "General East and South Elevations", BGE Drawing 62-006-E, Rev.4.

(B9) "Equipment Location Turbine Building Unit 1 Plan Floor El 12'0" ", BGE Drawing 60-207-E Rev.11.

(B10) "ARCON96: Atmospheric Relative Concentrations in Building Wakes", CA03940, 8/21/97.

(B11) "Heating and Ventilation System, Auxiliary Building, El. 69'0", Sections and Details", BGE Drawing 60-330-E, Rev.14.

(B12) "Wind Tunnel Modeling of CCNPP", CA00748 Rev.0, 10/25/95

(B13) "ARCON95 X/Q Analysis", Bechtel Calculation M-97-02 Rev.0, 5/8/97.

(B14) "ARCON95 X/Q Analysis", Bechtel Calculation M-97-03 Rev.0, 7/1/97.

(B15) "Analytical Software Installation Test of ARCON96", CA03941, 8/21/97.

9. METHOD OF ANALYSIS

This work utilizes three separate methodologies to calculate mass transfer from the spill site to the control room.

(1) The first methodology is diffusion in still air for spills in closed areas and for liquids with high boiling points. The method of analysis utilizes the algorithms of Ref.15 to derive the toxic gas concentration inside the control room.

(1a) Calculation of the Diffusion Coefficient of an air/toxic gas system for dilute gases at low pressures per Ref.13 by the method of Wilke and Lee:

$DAB = B'*TA^{1.5}*MR^{0.5}/(PA*SIGAB^{2}*OMEGA)$

where

DAB = Diffusion coefficient (cm^{2}/sec)
B' = $0.00217 - 0.00050 * (1/MA + 1/MB)^{0.5}$
MA = Molecular weight of air (gm/mole)
MB = Molecular weight of toxic gas (gm/mole)
MR = (MA+MB)/(MA*MB) = Molecular weight of binary gas (gm/mole)
TA = Air temperature (K)
PA = Air pressure (atm)
SIGAB = Characteristic length of molecule A interacting with molecule B (A)
= (SIGA+SIGB)/2
SIGA = Characteristic length of molecule A (A)
SIGB = Characteristic length of molecule B (A) = $1.18*VB^{1/3}$
VB = Lebas molal volume (cc/mol)
OMEGA = Collision integral

The Lebas molal volume VB can be calculated as follows per Ref.13:

VB = 14.8*(C) + 3.7*(H) + 7.4*(O) + 9.1*(O in Methyl Esters or Ethers)
+ 9.9*(O in Ethyl Esters or Ethers) + 11*(O in Higher Esters or Ethers)
+ 12*(O in Acids) + 8.3*(O Joined to S, P, N) + 15.6*(N Double Bonded)
+ 10.5*(N in Primary Amines) + 12*(N in Secondary Amines) + 27*(Br)
+ 24.6*(Cl) + 8.7*(F) + 37*(I) + 25.6*(S) - 6.0*(3-Membered Ring)
- 8.5*(4-Membered Ring) - 11.5*(5-Membered Ring) - 15*(6-Membered Ring)
- 30*Naphthalene - 47.5*Anthracene + (Molecular weight/density)*(Element)

The collision integral OMEGA can be calculated as follows per Ref.13:

$OMEGA = A/TS^{B} + C/e^{TS*D} + E/e^{TS*F} + G/e^{TS*H}$
A = 1.06036
B = 0.15610
C = 0.19300
D = 0.47635
E = 1.03587
F = 1.52996
G = 1.76474
H = 3.89411
TS = TA/(E/KAB)
E/KAB = SQRT(E/KA * E/KB)
E/KB = 1.15*(TB+273.15)

(1b) Surface Area of a Spill Per Ref.15

The rate of mass transfer of a liquid into the atmosphere is directly proportional to the surface area of the spill. Ref.15 approximates the initial shape of the liquid body by a cylinder, with the height equal to the radius of the base.

$V0(m^3) = Q*QF*(0.003785422\ m^3/gal)$

$R0(m) = (V0/\pi)^{1/3}$

$A0(m^2) = \pi*R0^2$

The liquid spreads quickly by gravity to a thin pancake on the ground. Its surface area may be estimated by the following equation:

$A(m^2) = \pi*(R0^2+2*t*(g*V0*(SG-RHOA)/(\pi*SG))^{0.5})$

where

SG = Density of the liquid (gm/cc)
g = Gravitational constant = 9.81 m/sec^2
t = Time (sec)

The surface area, however, does not expand indefinitely as the above equation indicates. The maximum area of the spill in an unconfined space is estimated from the initial volume by assuming a spill thickness of 1 cm.

$AF(m^2) = V0/0.01$

tA(sec) = Time to maximum area
= $(AF-A0)/SQRT(4*\pi*g*V0*(SG-RHOA)/SG)$

The total mass of the liquid can be calculated as follows:

$M0 = Q*QF*SG*3785.422\ gm$

where
Q = Storage quantity (gal)
QF = Volume fraction of liquid or weight fraction of solid
SG = Specific gravity (gm/cc)

(1c) Vaporization Rate in Still Air:

When exposed to the atmosphere, liquids with boiling points above the ambient temperature will evaporate by diffusion into the air. The main driving force is the vapor pressure difference, i.e., concentration gradient, between the liquid phase and the air. The rate of a vapor diffusing into still air is computed from the Fickian diffusion equation in Ref.15

$VR(gm/m^2\text{-}sec) = VP * RHOV * 10000. / p * SQRT(DAB/(\pi*t))$

where

VP(torr) = Vapor pressure of the liquid
p(torr) = Ambient atmospheric pressure (760 torr)
RHOV(gm/cc) = Vapor density of the liquid
t(sec) = Time
DAB(cm^2/sec) = Diffusion coefficient

The vapor density of the liquid RHOV is derived from Ref.14 as follows:

RHOV(lbm/cf) = 144*P'(psia)/(R*T(R))

RHOV(gm/cc) = 144*14.696/(1545/MB*T(R))*(.01601846 gm/cc/lbm/cf)
= MB(gm/mole) * 14.696*.01601846/(10.7292*T(R))

(1d) The vapor density outside the control room can be calculated via

VD(gm/m^3) = VR(gm/m^2-sec)*AF(m^2)*X/Q(sec/m^3)

The corresponding vapor density outside the control room in ppm is (Ref.13)

PPM = (24500/MB) * VD(gm/m^3)

(1e) The vapor concentration inside the control room at time t can be calculated via the following: $dC_{CR}/dt = \lambda * C_{EXT} - \lambda * C_{CR}$

for $t<t_R$ $\quad C_{CR1} = C_{EXT} * (1. - \exp(-\lambda * t))$

for $t_R<t<t_{max}$ $\quad C_{CR2} = C_{EXT} * \{1. - \exp[-\lambda * (t-t_R)]\} + C_{CR1} * \exp[-\lambda * (t-t_R)]$

for $t>t_{max}$ $\quad C_{CR3} = C_{R2} * \exp[-\lambda * (t-t_{max})]$

where

C_{CR} = Control room concentration in gm/m^3 or ppm
C_{EXT} = External concentration in gm/m^3 or ppm
λ = F_{CR} / V_{CR} = Turnover constant in 1/min at time t
F_{CR} = Control room ingress and egress flow rate at time t
V_{CR} = Control room volume
t = Time (min)
t_R = Time at which recirculation starts (min)
t_{max} = Time at which evaporation of toxic substance ceases (min)
= SG(gm/cc) * (1.cm) / {VR(gm/m^2-sec) * (0.0001 m^2/cm^2) * (60.sec/min)}

(1f) The spill area, vaporization rate, and vapor density are time-dependent quantities for diffusion in still air for spills in closed areas. The peak vapor density occurs at the time to maximum area (tA), which should be used under these conditions.

(2) The second methodology is mass transfer to forced convection for laminar flow per Ref.15.

VD(gm/m3) = VFL*ADC*AF (1. - exp(-λ * t))
PPM = (24500/MB)*VD

where
ADC = Atmospheric dispersion coefficient (sec/m3)
AF = Final spill area (m2) See 1b.
MB = Toxic gas molecular weight (gm/mole)
VFL = Laminar evaporation rate (gm/m2-sec)
= HDL*MB*VP*10000./(R*(T(C)+273.15))
T(C) = Temperature in °C at which VP is determined
VP = Toxic gas vapor pressure (mmHg)
TA = Ambient air temperature (C)
R = Universal gas constant = 62400 torr-cm3/gmole-K
HDL = Laminar mass transfer coefficient (cm/sec)
= $0.664*(DAB/L)*Re^{0.5}*Sc^{0.3333}$
DAB = Diffusion coefficient (cm2/sec) See 1a.
L = Characteristic length (cm)
= $(4*V0*1.E6/\pi)^{0.5}$
V0= Initial volume (m3) -See 1b.
Re= Reynolds number
= L*VW*RHOA/MU
VW = Wind velocity (cm/sec)
RHOA = Mass density of air
MU = Viscosity of air
Sc = Schmidt number
= MU/(DAB*RHOA)
λ = F_{CR} / V_{CR} = Turnover constant in 1/min
F_{CR} = Control room ingress and egress flow rate
V_{CR} = Control room volume
t = Time to maximum concentration = 10000.*SG/VFL

(3) The third methodology is mass transfer to forced convection for turbulent flow per Ref.15.

VD(gm/m3) = VFT*ADC*AF (1. - exp($-\lambda$ * t))
PPM = (24500/MB)*VD

where
ADC = Atmospheric dispersion coefficient (sec/m3)
AF = Final spill area (m2) See 1b.
MB = Toxic gas molecular weight (gm/mole)
VFT = Turbulent evaporation rate (gm/m2-sec)
= HDT*MB*VP*10000./(R*(T(C)+273.15))
VP = Toxic gas vapor pressure (mmHg)
TA = Ambient air temperature (C)
R = Universal gas constant = 62400 torr-cm3/gmole-K
HDT = Turbulent mass transfer coefficient (cm/sec)
= $0.037*(DAB/L)*Re^{0.8}*Sc^{0.3333}$
DAB = Diffusion coefficient (cm2/sec) See 1a.
L = Characteristic length (cm)
= $(4*V0*1.E6/\pi)^{0.5}$
V0 = Initial volume (m3) -See 1b.
Re= Reynolds number
= L*VW*RHOA/MU
VW = Wind velocity (cm/sec)

RHOA = Mass density of air
MU = Viscosity of air
Sc = Schmidt number
= MU/(DAB*RHOA)
λ = F_{CR} / V_{CR} = Turnover constant in 1/min
F_{CR} = Control room ingress and egress flow rate
V_{CR} = Control room volume
t = Time to maximum concentration = 10000.*SG/VFT

(04) Explosion and Flammability Limits:

Comparison of the maximum concentration of the relevant toxic chemical concentration inside the control room should yield a limiting value with which to compare against the explosion and flammability limits.

10. CALCULATIONS

The chemical concentration of 35% hydrazine inside the control room for a chemical spill of 375 gal in the tank farm/warehouse/north service building is calculated via EXCEL spreadsheets captured in the following attachments using the methodologies of Section 9:

Attachment D: 35% Hydrazine Solution for Current Control Room Configuration

Attachment E: 35% Hydrazine Solution for Modified Control Room Configuration

11. DOCUMENTATION OF COMPUTER CODES

This work employed the ARCON96 computer code, which was verified, benchmarked, and documented in Ref.B10. The installation is documented in Ref.B15. ARCON96 implements a computational model for calculating atmospheric dispersion coefficients (X/Q's) in the vicinity of buildings.

12. RESULTS

The results of the toxicity calculations for a 35% hydrazine solution are as follows:

		Peak Concentration (ppm)		
		Tank Farm	Warehouse	NSB
Current Configuration	No Recirculation	0.88	0.25	2.80
	With Recirculation	0.88	0.25	2.80
Modified Configuration	With Recirculation	0.57	0.29	0.84
Toxicity Limit (IDLH)		80	80	80

Note that under the current and modified configurations, the peak control room concentration under worst case conditions is less than the IDLH toxicity limit, the maximum level from which one could escape within 30 minutes without any impairing symptoms or irreversible health effects.

13. CONCLUSIONS

Based on the spreadsheet results presented in Attachments D and E, use and storage of a 35% Hydrazine Solution at the tank farm/warehouse/north service building in a 375 gallon tote bin does not present any control room radiological habitability concerns at CCNPP. Hydrazine will not pose a flammability or explosion hazard in the control room, since the peak concentration is a small fraction of the lower explosion limit.

The current chemical habitability calculation incorporates many assumptions which make these results conservative.
(1) A maximum concentration limit (IDLH) was utilized that could be tolerated for 30 minutes without physical incapacitation of an average human. The regulatory requirements of Ref.2 dictate a maximum concentration limit that could be tolerated for 2 minutes without physical incapacitation of an average human. IDLH denotes Immediately Dangerous to Life and Health and is defined as the maximum level from which one could escape within 30 minutes without any impairing symptoms or irreversible health effects (Ref.5).
(2) For the current configuration the maximum control room intake flowrate of 8300 cfm is utilized. This value is twice the normal operating value. (Refs.6-8)
(3) The control room volume conservatively neglects dead spaces in the control room ceiling and the volume of room A512.
(4) The most conservative methodology is utilized: turbulent evaporation.

14. ATTACHMENTS

ATTACHMENT A
MSDS FOR HYDRAZINE

Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8854

Material Safety Data Sheets Collection:

Sheet No. 126
Hydrazine

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Issued: 6/84 Revision: A, 4/90 Errata Date: 7/9

Section 1. Material Identification

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Hydrazine Description: Prepared by a two-step process: 1) reaction of sodium hypochlorite and ammonia to yield sodium hydroxide and chloramine (NH_2Cl), then 2) reaction of chloramine, sodium hydroxide, and ammonia to yield hydrazine, sodium chloride, and water. These processes are carried out in the presence of such colloidal materials as glue or starch to prevent unwanted side reactions. There are two forms: anhydrous and hydrate. Hydrazine anhydrous is used as a reducing agent for many transition metals and some nonmetals, a high-energy rocket fuel, a corrosion inhibitor in boiler feedwater and reactor cooling water, a polymerization catalyst, a chemical intermediate for blowing agents, a scavenger for gases, an antioxidant, a shortstopping agent; in electrolytic plating of metals on glass and plastics, wastewater treatment, nuclear fuel reprocessing, drugs, agricultural chemicals, photographic developer, fuel cells, dyes, explosives, metallurgy, spandex fibers, diving equipment, pesticides and solder fluxes. Hydrazine hydrate is used as a chemical intermediate, a catalyst, and a solvent for inorganic materials.
Other Designations: CAS No. 302-01-2 (anhydrous), H_2NNH_2; CAS No. 7803-57-8 (hydrate), $NH_2NH_2 \cdot H_2O$; hydrazine base; diamine; diamide hydrate.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

Hydrate
Genium
3
3 2
-

Anhydrous
NFPA
3
3 2
-

R 1
I 4
S 3*
K 3
* Skin absorption

HMIS
H 3
F 0
R 0
PPG†
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Hydrazine, 99%

OSHA PEL (Skin)
8-hr TWA: 0.1 mg/m³

ACGIH TLV (Skin), 1989-90
TLV-TWA: 0.1 mg/m³

NIOSH REL, 1987
120-min ceiling: 0.04 mg/m³

Toxicity Data*
DNA inhibition, human: HeLa cell; 50 mol/L
Rat, inhalation, TC_{Lo}: a 1-ppm dose administered intermittently within 6-hr periods over a year showed it is an equivocal tumorigenic agent causing olfaction tumors
Mouse, oral, TD_{Lo}: 1951 mg/kg ingested continuously over 2 yr affected the lungs, thorax, respiration (tumors), and blood (lymphoma)

* See NIOSH, *RTECS* (MU7175000, anhydrous; MV8050000, hydrate), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 236.3 °F/113.5 °C,* 245.3 °F/118.5 °C at 740 mm†
Melting Point: 34.5 °F/1.4 °C,* -61.1 °F/-51.7 °C†
Vapor Pressure: 14.4 mm Hg at 77 °F/25 °C*
Vapor Density (Air = 1): 1.1*
Molecular Weight: 32.06 g/mol,* 50.08 g/mol†
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.011 at 59 °F/15 °C,* 1.03 at 70 °F/21 °C†
Water Solubility: Both are miscible in water

Appearance and Odor: Colorless, fuming, oily, hygroscopic (moisture-absorbent) liquid or white crystals with a penetrating, fishy, ammonia-like odor.* Colorless, fuming (64% hydrazine hydrate fumes in air), refractive liquid with ammonia-like odor.† Both have a 3- to 4-ppm odor threshold. Sense of smell can be rapidly desensitized; not considered to have good warning properties. Take immediate protective action if odor or irritancy is detected.

* Anhydrous
† Hydrate (Various concentrations of hydrazine hydrate exist and their physical properties vary respectively).

Section 4. Fire and Explosion Data

Flash Point: 100 °F/37.8 °C OC,* 73 °F/163 °C OC† (64%), 89° F/192 °C OC† (54.4 %)	**Autoignition Temperature:** Can vary with contact surface‡	**LEL:** 2.9% v/v*	**UEL:** 98% v/v*

Extinguishing Media: If this material is afire or involved in a fire, do not extinguish unless the flow of material can be stopped. Use water in flooding amounts as fog, or alcohol foam, carbon dioxide, or dry chemical to dilute spills to nonflammable mixtures and to disperse vapors.
Unusual Fire or Explosion Hazards: Hydrazine is a severe explosion hazard when exposed to heat or by reaction with oxidizers. Its vapor is exceptionally hazardous because once ignited it continues to burn by exothermic decomposition in complete absence of air or oxidant. The vapors may also travel to an ignition source and flash back. The combustion of hydrazine yields 148.6 kcal/mol (heat), nitrogen and water are products. This material may also ignite spontaneously when in contact with porous materials such as wood, asbestos, earth, or cloth.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and wear a fully encapsulating suit. Apply water from as far a distance as possible. If fire becomes uncontrollable or if containers are exposed to direct flames, evacuate for a 2500-ft radius. Cool containers with flooding amounts of water. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

*Anhydrous
† Hydrate
‡ The autoignition temperature for hydrazine (anhydrous) can vary from 74 °F /23 °C in contact with iron rust, to 270 °F/132 °C in contact with black iron, to 313 °F/156 °C in contact with stainless steel, and to 518 °F/270 °C in contact with glass.

Section 5. Reactivity Data

Stability/Polymerization: Hydrazine is stable at room temperature in closed containers under normal storage and handling conditions under an inert atmosphere in the absence of UV radiation. Hazardous polymerization cannot occur. This material is neither shock or friction sensitive. Keep out of direct sunlight. **Chemical Incompatibilities:** Hydrazine is a highly active reducing agent, especially under basic conditions. It is incompatible with oxidizing agents (including air), acids, some metal oxides (such as iron, copper, lead, molybdenum) and some metals (carbon steel, copper, zinc). Solutions can attack glass, polyethylene, graphite, chrome plate, rubber, and cork. It ignites spontaneously in air in contact with porous materials. Ignites on contact with dinitrogen oxide, hydrogen peroxide, dinitrogen tetraoxide, N,2,4,6-tetranitroaniline, rhenium + alumina, cotton waste + heavy metals, nitric acid, rust + heat, and catalysts. Violent reaction with thiocyanate, 1-chloro-2,4-dinitobenzene, thiocarbonyl azide. Vigorous reaction with benzene-seleninic acid or anhydride, potassium peroxodisulfate, ruthenium (III) chloride, and carbon dioxide + stainless steel. Explodes on contact with titanium compounds (at 130 °C), dicyanofurazan, trioxygen difluoride, silver compounds, N-halomides, potassium, sodium hydroxide. Forms sensitive explosive mixtures with metal salts, methanol + nitromethane, 2-chloro-5-methylnitrobenzene, sodium, air, sodium perchlorate, and lithium perchlorate. **Hazardous Products of Decomposition:** Thermal oxidative decompositio of hydrazine can produce highly toxic fumes of nitrogen oxides (NO_x) and ammonia (NH_3).

Section 6. Health Hazard Data

Carcinogenicity: The ACGIH, NTP, and IARC list hydrazine as, respectively, a suspected, anticipated, and possible (Group 2B; based on sufficient animal evidence) human carcinogen. **Summary of Risks:** Hydrazine is poisonous by ingestion, skin contact, intravenous, intraperitoneal, and inhalation. The hydrazine concentration considered immediately dangerous to life and health (IDLH) is 80 ppm. In general, hydrazines are local irritants and convulsants that may damage the liver and destroy red blood cells. As well as a systemic poison, hydrazine is a skin sensitizer. This material is corrosive to the eyes, skin, and mucous membranes. Experimental studies show hydrazine is a possible carcinogen, neoplastigen (a tumor-forming agent, usually malignant), teratogen (a fetus-harming agent), and tumorigen of the lungs, liver, kidney, nervous system, breast, hematopoiectic (involved in formation of blood or its cells in the living body) organs, and subcutaneous (beneath the skin) tissue. It is reported that a worker who handled hydrazine hydrate once a week for 6 months developed symptoms of fever, lethargy, diarrhea, vomiting, abdominal pains, incoherency, and black stools. He died 20 days after his last exposure due to kidney damage and pulmonary edema. **Medical Conditions Aggravated by Long-Term Exposure:** Damage to the liver, kidney, and blood (characterized by hemolysis and reduction of packed cell volume). Cancer, fetal malformations, and embryolethlity are observed in laboratory animals. **Target Organs:** Central nervous system, respiratory system, liver, kidney, blood, skin, eyes. **Primary Entry Routes:** Inhalation, ingestion. **Acute Effects:** An acute exposure to hydrazine may cause vomiting, diarrhea, nausea, dizziness, cyanosis, and convulsions. Hydrazine inhalation causes severe irritation of the eyes, skin, and respiratory tract. Eye irritation includes swelling, burning, redness, and discharge. Liquid contact can produce penetrating burns and possible permanent corneal opacity with visual impairment. Temporary blindness may occur with a severe exposure. Hydrazine can produce severe burns to the skin and possible dermatitis. Inflammation of the respiratory tract may lead to bronchitis, pulmonary edema, and even lung damage. Ingestion of hydrazine irritates and burns the entire gastrointestinal tract and is characterized by vomiting, abdominal pain, diarrhea, bleeding, and tissue ulceration. **Chronic Effects:** Repeated hydrazine inhalation produces inflammation of the nasal, tracheal, and bronchial tissue resulting in chronic bronchitis. Repeated skin exposure can cause dermatitis with a characteristic rash.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person immediately drink large quantities of water, then induce vomiting.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Physician's Note: Unless the patient is comatose or convulsing, vomiting may be induced if initiated within 30 min after ingestion. If vomiting is unsuccessful after 2 doses of Ipecac, the decision to lavage should be made on an individual basis. Pyridoxine may be antidotal for coma. Use IV diazepam to treat seizures.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a spill control countermeasure plan (SCCP).* Notify safety personnel of spills, evacuate all unnecessary personnel, remove heat and ignition sources, and provide optimum explosion-proof ventilation. To control the fire hazard, promptly dilute the spill to less than 40% hydrazine. Flush diluted hydrazine and contain and collect the liquid. Use sand or noncombustible absorbent to collect small spills. Place waste in closed disposal containers. Flush spill area with water, but be aware of runoff to sewers and waterways. A 4.3-mg/l concentration of hydrazine during a 96-hr test period is the median tolerance limit (TLm 96) at which 50% of *Salmo gairdneri* survive. Follow applicable OSHA regulations (29 CFR 1910.120). **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33);Hazardous Waste No. U133
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per RCRA, Sec. 3001]
Listed as a SARA Extremely Hazardous Substance (40 CFR 355), Reportable Quantity (RQ): 1 lb; Threshold Planning Quantity (TPQ): 1000 lb
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. **Warning:** Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Butyl rubber is recommended for impervious body-covering protection. **Ventilation:** Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the established OSHA PEL, ACGIH TLV, and NIOSH REL. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing. Contaminated clothing and equipment are a fire and health hazard. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a clean, cool, well-ventilated area with controlled drainage, away from oxidizing agents, acids, all incompatible materials (Sec. 5), direct sunlight, and heat and ignition sources. Water sprinkler protected, sheltered, outside, or detached storage preferred. Protect containers from physical damage. All engineering systems should be of maximum explosion-proof design and electrically ground and bound to prevent static sparks. Maintain an inert atmosphere (nitrogen) over this material to avoid gradual oxidation. Prevent contamination of hydrazine. **Engineering Controls:** Prevent liquid contact with eyes, skin, or clothing. Avoid inhaling vapors. Use only with proper personal protective gear and adequate ventilation. Practice good personal hygiene procedures. Hydrazine is a very sensitive material that must not be used without full and complete instructions from the manufacturer.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Hydrazine, anhydrous,* *or* Hydrazine, aqueous†
DOT Hazard Class: Flammable liquid,* Corrosive material†
ID No.: UN2029,* UN2030†
DOT Label: Flammable liquid and poison,* Corrosive†
DOT Packaging Requirements: 173.276 (Both)
DOT Packaging Exceptions: None (Both)

IMO Shipping Name: Hydrazine, anhydrous, *or* Hydrazine, aqueous solutions, with more than 64% hydrazine by weight.* Hydrazine, hydrate, *or* Hydrazine, aqueous solutions, with not more than 64% hydrazine by weight†
IMO Hazard Class: 3.3,* 8†
IMO Label: Flammable Liquid, Poison, Corrosive,* Corrosive, Poison†
IMDG Packaging Group: I,* II†
ID No.: UN2029*, UN2030†

*Anhydrous
† Hydrate

MSDS Collection **References:** 1-12, 14, 16, 19, 20, 23, 25, 26, 31, 38, 42, 47-49, 52, 73, 84-85, 87, 88-89, 100, 103, 109, 123, 124, 126, 127, 129, 131-132

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

HYDRAZINE

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HDZ

Common Synonyms	Watery liquid / Colorless / Ammonia odor Mixes with water. Poisonous, flammable vapor is produced. Freezing point is 35°F.

AVOID CONTACT WITH LIQUID AND VAPOR. Keep people away.
Wear chemical protective suit with self-contained breathing apparatus.
Stop discharge if possible. Call fire department.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire	FLAMMABLE Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Wear chemical protective suit with self-contained breathing apparatus Combat fires from safe distance or protected location. Flood discharge area with water. Extinguish with dry chemical, alcohol foam, or carbon dioxide Cool exposed containers with water. Continue cooling after fire has been extinguished.
Exposure	CALL FOR MEDICAL AID. **VAPOR** **POISONOUS IF INHALED OR IF SKIN IS EXPOSED.** Irritating to eyes. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. **LIQUID** **POISONOUS IF SWALLOWED OR IF SKIN IS EXPOSED.** Will burn eyes. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-high flammability, corrosive
Restrict access
Chemical and physical treatment

2. LABEL

2.1 **Category:** Flammable liquid
2.2 **Class:** 3

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Not listed
3.2 **Formula:** N_2H_4
3.3 **IMO/UN Designation:** 6.0/2030
3.4 **DOT ID No.:** 2030
3.5 **CAS Registry No.:** 302-01-2

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Ammonia-like

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Ammonia-type gas mask; self-contained breathing apparatus; plastic-coated or rubber gloves, clothes, and apron; safety shower must be available.
5.2 **Symptoms Following Exposure:** Vapors cause itching, swelling, and blistering of eyelids, skin, nose and throat; symptoms may be delayed for several hours. Temporary blindness may occur. Liquid causes a caustic-like burn if not washed off at once. Ingestion or absorption through skin causes nausea, dizziness, headache. Severe exposure may cause death.
5.3 **Treatment of Exposure:** Call a doctor at once. INHALATION: remove to fresh air; observe for development of delayed symptoms. Keep quiet. INGESTION: do NOT induce vomiting; give egg whites or other emollient. SKIN OR EYES: wash with large amounts of water for at least 15 min.
5.4 **Threshold Limit Value:** 0.1 ppm
5.5 **Short Term Inhalation Limits:** 1 ppm for 30 min.
5.6 **Toxicity by Ingestion:** Grade 3; LD_{50} = 50 to 500 mg/kg (rat)
5.7 **Late Toxicity:** Causes lung cancer in mice.
5.8 **Vapor (Gas) Irritant Characteristics:** Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations.
5.9 **Liquid or Solid Irritant Characteristics:** Severe skin irritant. Causes second-and third-degree burns on short contact; very injurious to the eyes.
5.10 **Odor Threshold:** 3-4 ppm
5.11 **IDLH Value:** 80 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 100°F O.C.
6.2 **Flammable Limits in Air:** 4.7%-100%
6.3 **Fire Extinguishing Agents:** Water, alcohol foam, carbon dioxide, or dry chemical
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Toxic vapor is generated when heated.
6.6 **Behavior in Fire:** May explode if confined.
6.7 **Ignition Temperature:** May ignite spontaneously 518°F (glass)
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** 1 mm/min. (est.)
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** Can catch fire when in contact with porous materials such as wood, asbestos, cloth, earth and rusty metals.
7.3 **Stability During Transport:** Stable at ordinary temperatures. When heated, can decompose to nitrogen and ammonia gases, but decomposition is not hazardous unless material is confined.
7.4 **Neutralizing Agents for Acids and Caustics:** Flush with water. Neutralize the resulting solution with calcium hypochlorite (HTH) (7 lbs per lb of hydrazine).
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent

(Continued)

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 146 ppm/0.5 hr/rainbow trout/died/fresh water
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** 100%
8.4 **Food Chain Concentration Potential:** None

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Anhydrous; 35-64% water solutions
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** Padded
9.4 **Venting:** Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-P-Q

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Flammable liquid
11.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	4
Health	
Vapor Irritant	3
Liquid or Solid Irritant	4
Poisons	4
Water Pollution	
Human Toxicity	4
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	4
Water	0
Self Reaction	4

11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	3
Flammability (Red)	3
Reactivity (Yellow)	2

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Liquid
12.2 **Molecular Weight:** 32.05
12.3 **Boiling Point at 1 atm:** 236.3°F = 113.5°C = 386.7°K
12.4 **Freezing Point:** 34.7°F = 1.5°C = 274.7°K
12.5 **Critical Temperature:** 716°F = 380°C = 653°K
12.6 **Critical Pressure:** 2130 psia = 145 atm = 14.7 MN/m^2
12.7 **Specific Gravity:** 1.008 at 20°C (liquid)
12.8 **Liquid Surface Tension:** Not pertinent
12.9 **Liquid Water Interfacial Tension:** Not pertinent
12.10 **Vapor (Gas) Specific Gravity:** Not pertinent
12.11 **Ratio of Specific Heats of Vapor (Gas):** 1.191
12.12 **Latent Heat of Vaporization:** 538 Btu/lb = 299 cal/g = 12.5 X 10^5 J/kg
12.13 **Heat of Combustion:** —8345 Btu/lb = —4636 cal/g = —194.1 X 10^5 J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** —218 Btu/lb = —121 cal/g = —5.07 X 10^5 J/kg
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data not available
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** Data not available

7. CHEMICAL REACTIVITY (Continued)

7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** Data not available

ATTACHMENT B
ARCON96 RUNS FOR AUX BLDG ROOF INLET

```
Program Title:  ARCON96.

Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management

Date:           June 25, 1997    11:00 a.m.

NRC Contacts:   J. Y. Lee        Phone: (301) 415 1080
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Code Developer: J. V. Ramsdell   Phone: (509) 372 6316
                                 e-mail: j_ramsdell@pnl.gov

Code Documentation:  NUREG/CR-6331 Rev. 1

The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.

Program Run   7/23/1998  at  07:33:16

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  3
    Meteorological Data File Names
      CC1991.MET
      CC1992.MET
      CC1993.MET

    Height of lower wind instrument  (m)  =      10.0
    Height of upper wind instrument  (m)  =      60.0
    Wind speeds entered as meters/second

    Ground-level release
    Release height  (m)                    =        .0
    Building Area  (m^2)                   =    1155.0
    Effluent vertical velocity  (m/s)      =       .00
    Vent or stack flow  (m^3/s)            =       .00
    Vent or stack radius  (m)              =      6.72

    Direction .. intake to source (deg)  =       333
    Wind direction sector width  (deg)   =        90
    Wind direction window  (deg)         =    288 - 018
    Distance to intake  (m)              =     135.0
    Intake height   (m)                  =      15.6
    Terrain elevation difference  (m)    =        .0

    Output file names
      CHTFCR.out
      CHTFCR.jfd

    Minimum Wind Speed  (m/s)              =        .5
    Surface roughness length  (m)          =       .10
    Sector averaging constant              =       4.0

    Initial value of sigma y               =      3.12
    Initial value of sigma z               =       .00

    Expanded output for code testing not selected

    Total number of hours of data processed =  26307
    Hours of missing data                   =    416
    Hours direction in window               =   7167
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  18229

    DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL
  AVER. PER.          1          2          4          8         12         24         96        168        360        720
  UPPER LIM.   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03
    LOW LIM.   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07
```

```
ABOVE RANGE        0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
   IN RANGE     7662.      9147.     11079.     13554.     15606.     19559.     25004.     25103.     25169.     24910.
BELOW RANGE        0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
       ZERO    18229.     16678.     14628.     11932.     10062.      6025.       201.         1.         0.         0.
 TOTAL X/Qs    25891.     25825.     25707.     25486.     25668.     25584.     25205.     25104.     25169.     24910.
 % NON ZERO    29.59      35.42      43.10      53.18      60.80      76.45      99.20     100.00     100.00     100.00

  95th PERCENTILE X/Q VALUES
             3.33E-04   3.29E-04   3.19E-04   2.97E-04   2.45E-04   1.83E-04   1.10E-04   9.83E-05   8.55E-05   7.73E-05

  95% X/Q for standard averaging intervals

  0 to 2 hours          3.33E-04
  2 to 8 hours          2.84E-04
  8 to 24 hours         1.26E-04
  1 to 4 days           8.55E-05
  4 to 30 days          7.22E-05

                              HOURLY VALUE RANGE
                            MAX X/Q                    MIN X/Q
        CENTERLINE          4.59E-04                   4.23E-05
        SECTOR-AVERAGE      2.88E-04                   2.65E-05

NORMAL PROGRAM COMPLETION
```

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CA04542 REV 0
PAGE 30

```
Program Title:  ARCON96.

Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management

Date:           June 25, 1997    11:00 a.m.

NRC Contacts:   J. Y. Lee        Phone: (301) 415 1080
                                 e-mail: jyl1@nrc.gov
                J. J. Hayes      Phone: (301) 415 3167
                                 e-mail: jjh@nrc.gov
                L. A  Brown      Phone: (301) 415 1232
                                 e-mail: lab2@nrc.gov

Code Developer: J. V. Ramsdell   Phone: (509) 372 6316
                                 e-mail: j_ramsdell@pnl.gov

Code Documentation:  NUREG/CR-6331 Rev. 1

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use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.

Program Run   7/23/1998  at  07:33:48

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  3
    Meteorological Data File Names
      CC1991.MET
      CC1992.MET
      CC1993.MET

    Height of lower wind instrument  (m)  =      10.0
    Height of upper wind instrument  (m)  =      60.0
    Wind speeds entered as meters/second

    Ground-level release
    Release height  (m)                    =         .0
    Building Area  (m^2)                   =     1155.0
    Effluent vertical velocity  (m/s)      =        .00
    Vent or stack flow   (m^3/s)           =        .00
    Vent or stack radius  (m)              =       6.72

    Direction .. intake to source (deg)   =       174
    Wind direction sector width (deg)     =        90
    Wind direction window  (deg)          =    129 - 219
    Distance to intake  (m)               =     300.0
    Intake height   (m)                   =      15.6
    Terrain elevation difference  (m)     =        .0

    Output file names
      CHWHCR.out
      CHWHCR.jfd

    Minimum Wind Speed  (m/s)             =        .5
    Surface roughness length  (m)         =        .10
    Sector averaging constant             =       4.0

    Initial value of sigma y              =       3.12
    Initial value of sigma z              =        .00

    Expanded output for code testing not selected

    Total number of hours of data processed =  26307
    Hours of missing data                   =    416
    Hours direction in window               =   7071
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  18325

    DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL
  AVER. PER.          1          2          4          8         12         24         96        168        360        720
  UPPER LIM.   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-04   1.00E-04   1.00E-04   1.00E-04   1.00E-04   1.00E-04
    LOW LIM.   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-08   1.00E-08   1.00E-08   1.00E-08   1.00E-08   1.00E-08
```

```
ABOVE RANGE        0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
   IN RANGE     7566.      9072.     10985.     13503.     15536.     19375.     24850.         0.         0.         0.
BELOW RANGE        0.         0.         0.         0.         0.         0.         0.     25104.     25169.     24910.
       ZERO    18325.     16753.     14722.     11983.     10132.      6209.       355.         0.         0.         0.
 TOTAL X/Qs    25891.     25825.     25707.     25486.     25668.     25584.     25205.         0.         0.         0.
 % NON ZERO    29.22      35.13      42.73      52.98      60.53      75.73      98.59     25104.     25169.     24910.
                                                                                          100.00     100.00     100.00

  95th PERCENTILE X/Q VALUES
             9.17E-05   8.93E-05   8.65E-05   8.09E-05   6.65E-05   4.83E-05   2.90E-05   2.47E-05   2.20E-05   2.02E-05

  95% X/Q for standard averaging intervals

  0 to 2 hours        9.17E-05
  2 to 8 hours        7.74E-05
  8 to 24 hours       3.20E-05
  1 to 4 days         2.25E-05
  4 to 30 days        1.88E-05

                          HOURLY VALUE RANGE
                         MAX X/Q                MIN X/Q
      CENTERLINE         1.14E-04               1.05E-05
      SECTOR-AVERAGE     7.14E-05               6.55E-06

NORMAL PROGRAM COMPLETION
```

```
Program Title:  ARCON96.

Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management

Date:           June 25, 1997    11:00 a.m.

NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
                L. A  Brown     Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov

Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov

Code Documentation:  NUREG/CR-6331 Rev. 1

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party would not infringe privately owned rights.

Program Run   7/23/1998  at  07:32:33

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  3
    Meteorological Data File Names
      CC1991.MET
      CC1992.MET
      CC1993.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     60.0
    Wind speeds entered as meters/second

    Ground-level release
    Release height (m)                   =        .0
    Building Area (m^2)                  =    1155.0
    Effluent vertical velocity (m/s)     =       .00
    Vent or stack flow  (m^3/s)          =       .00
    Vent or stack radius (m)             =      6.72

    Direction .. intake to source (deg)  =      059
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =   014 - 104
    Distance to intake (m)               =     67.0
    Intake height  (m)                   =     15.6
    Terrain elevation difference (m)     =       .0

    Output file names
      CHNSBCR.out
      CHNSBCR.jfd

    Minimum Wind Speed (m/s)             =       .5
    Surface roughness length (m)         =       .10
    Sector averaging constant            =      4.0

    Initial value of sigma y             =      3.12
    Initial value of sigma z             =       .00

    Expanded output for code testing not selected

    Total number of hours of data processed =  26307
    Hours of missing data                   =    416
    Hours direction in window               =   5333
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  20063

    DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL
   AVER. PER.          1          2          4          8         12         24         96        168        360        720
   UPPER LIM.   1.00E-02   1.00E-02   1.00E-02   1.00E-02   1.00E-02   1.00E-02   1.00E-02   1.00E-02   1.00E-02   1.00E-02
     LOW LIM.   1.00E-06   1.00E-06   1.00E-06   1.00E-06   1.00E-06   1.00E-06   1.00E-06   1.00E-06   1.00E-06   1.00E-06
```

```
ABOVE RANGE        0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
   IN RANGE     5828.      7130.      8854.     11232.     13252.     17178.     24362.     24911.     25169.     24910.
BELOW RANGE        0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
       ZERO    20063.     18695.     16853.     14254.     12416.      8406.       843.       193.         0.         0.
 TOTAL X/Qs    25891.     25825.     25707.     25486.     25668.     25584.     25205.     25104.     25169.     24910.
 % NON ZERO    22.51      27.61      34.44      44.07      51.63      67.14      96.66      99.23     100.00     100.00

  95th PERCENTILE X/Q VALUES
            1.06E-03   1.03E-03   9.79E-04   8.92E-04   7.37E-04   5.45E-04   3.24E-04   2.76E-04   2.26E-04   1.99E-04

  95% X/Q for standard averaging intervals

  0 to 2 hours        1.06E-03
  2 to 8 hours        8.34E-04
  8 to 24 hours       3.71E-04
  1 to 4 days         2.51E-04
  4 to 30 days        1.80E-04

                            HOURLY VALUE RANGE
                          MAX X/Q                   MIN X/Q
       CENTERLINE         1.48E-03                  1.38E-04
       SECTOR-AVERAGE     9.29E-04                  8.65E-05

NORMAL PROGRAM COMPLETION
```

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ATTACHMENT C
ARCON96 RUNS FOR WEST ROAD INLET PLENUM

CA04542 REV 0
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```
Program Title:  ARCON96.

Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management

Date:           June 25, 1997    11:00 a.m.

NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
                L. A  Brown     Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov

Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov

Code Documentation:  NUREG/CR-6331 Rev. 1

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use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.

Program Run   7/23/1998  at  07:33:30

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  3
    Meteorological Data File Names
      CC1991.MET
      CC1992.MET
      CC1993.MET

    Height of lower wind instrument (m)  =      10.0
    Height of upper wind instrument (m)  =      60.0
    Wind speeds entered as meters/second

    Ground-level release
    Release height (m)                   =        .0
    Building Area (m^2)                  =    1155.0
    Effluent vertical velocity (m/s)     =       .00
    Vent or stack flow  (m^3/s)          =       .00
    Vent or stack radius (m)             =      6.72

    Direction .. intake to source (deg)  =       354
    Wind direction sector width (deg)    =        90
    Wind direction window (deg)          =   309 - 039
    Distance to intake (m)               =     172.0
    Intake height  (m)                   =       9.1
    Terrain elevation difference (m)     =        .0

    Output file names
      CHTFWR.out
      CHTFWR.jfd

    Minimum Wind Speed (m/s)             =        .5
    Surface roughness length (m)         =       .10
    Sector averaging constant            =       4.0

    Initial value of sigma y             =      3.12
    Initial value of sigma z             =       .00

    Expanded output for code testing not selected

    Total number of hours of data processed =  26307
    Hours of missing data                   =    416
    Hours direction in window               =   7470
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  17926

    DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL
    AVER. PER.        1         2         4         8        12        24        96       168       360       720
    UPPER LIM.  1.00E-03  1.00E-03  1.00E-03  1.00E-03  1.00E-03  1.00E-03  1.00E-03  1.00E-03  1.00E-03  1.00E-03
      LOW LIM.  1.00E-07  1.00E-07  1.00E-07  1.00E-07  1.00E-07  1.00E-07  1.00E-07  1.00E-07  1.00E-07  1.00E-07
```

```
 ABOVE RANGE         0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
    IN RANGE      7965.      9453.     11343.     13855.     15936.     19755.     25017.     25101.     25169.     24910.
 BELOW RANGE         0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
        ZERO     17926.     16372.     14364.     11631.      9732.      5829.       188.         3.         0.         0.
  TOTAL X/Qs     25891.     25825.     25707.     25486.     25668.     25584.     25205.     25104.     25169.     24910.
  % NON ZERO     30.76      36.60      44.12      54.36      62.09      77.22      99.25      99.99     100.00     100.00

   95th PERCENTILE X/Q VALUES
               2.15E-04   2.10E-04   2.05E-04   1.93E-04   1.60E-04   1.21E-04   7.67E-05   6.76E-05   5.83E-05   5.28E-05

   95% X/Q for standard averaging intervals

   0 to 2 hours         2.15E-04
   2 to 8 hours         1.85E-04
   8 to 24 hours        8.55E-05
   1 to 4 days          6.18E-05
   4 to 30 days         4.91E-05

                            HOURLY VALUE RANGE
                          MAX X/Q                MIN X/Q
        CENTERLINE        2.99E-04               2.88E-05
        SECTOR-AVERAGE    1.87E-04               1.80E-05

NORMAL PROGRAM COMPLETION
```

CA04542 REV 0
PAGE 37

```
Program Title:  ARCON96.

Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management

Date:           June 25, 1997    11:00 a.m.

NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
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Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
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Code Documentation:  NUREG/CR-6331 Rev. 1

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use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.

Program Run   7/23/1998  at  07:34:03

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  3
    Meteorological Data File Names
      CC1991.MET
      CC1992.MET
      CC1993.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     60.0
    Wind speeds entered as meters/second

    Ground-level release
    Release height (m)                    =        .0
    Building Area (m^2)                   =    1155.0
    Effluent vertical velocity (m/s)      =       .00
    Vent or stack flow  (m^3/s)           =       .00
    Vent or stack radius (m)              =      6.72

    Direction .. intake to source (deg)  =      162
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =   117 - 207
    Distance to intake (m)               =    262.0
    Intake height  (m)                   =      9.1
    Terrain elevation difference (m)     =       .0

    Output file names
      CHWHWR.out
      CHWHWR.jfd

    Minimum Wind Speed (m/s)              =        .5
    Surface roughness length (m)          =       .10
    Sector averaging constant             =      4.0

    Initial value of sigma y              =      3.12
    Initial value of sigma z              =       .00

    Expanded output for code testing not selected

    Total number of hours of data processed =  26307
    Hours of missing data                   =    416
    Hours direction in window               =   5698
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  19698

    DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL
   AVER. PER.        1          2          4          8         12         24         96        168        360        720
   UPPER LIM.   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03
     LOW LIM.   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07
```

```
ABOVE RANGE        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
   IN RANGE     6193.     7584.     9475.    12141.    14358.    18559.    24524.    25030.    25169.    24910.
BELOW RANGE        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
       ZERO    19698.    18241.    16232.    13345.    11310.     7025.      681.       74.        0.        0.
 TOTAL X/Qs    25891.    25825.    25707.    25486.    25668.    25584.    25205.    25104.    25169.    24910.
 % NON ZERO    23.92     29.37     36.86     47.64     55.94     72.54     97.30     99.71    100.00    100.00

  95th PERCENTILE X/Q VALUES
             1.10E-04  1.06E-04  1.01E-04  9.30E-05  7.56E-05  5.24E-05  3.00E-05  2.61E-05  2.30E-05  2.07E-05

  95% X/Q for standard averaging intervals

  0 to 2 hours        1.10E-04
  2 to 8 hours        8.73E-05
  8 to 24 hours       3.22E-05
  1 to 4 days         2.25E-05
  4 to 30 days        1.93E-05

                                HOURLY VALUE RANGE
                              MAX X/Q              MIN X/Q
        CENTERLINE            1.44E-04             1.44E-05
        SECTOR-AVERAGE        9.02E-05             9.02E-06

NORMAL PROGRAM COMPLETION
```

CA04542 REV 0
PAGE 35

```
Program Title:  ARCON96.

Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management

Date:           June 25, 1997    11:00 a.m.

NRC Contacts:   J. Y. Lee        Phone: (301) 415 1080
                                 e-mail: jyl1@nrc.gov
                J. J. Hayes      Phone: (301) 415 3167
                                 e-mail: jjh@nrc.gov
                L. A  Brown      Phone: (301) 415 1232
                                 e-mail: lab2@nrc.gov

Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                 e-mail: j_ramsdell@pnl.gov

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use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.

Program Run   7/23/1998  at  07:32:59

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  3
    Meteorological Data File Names
      CC1991.MET
      CC1992.MET
      CC1993.MET

    Height of lower wind instrument (m)  =      10.0
    Height of upper wind instrument (m)  =      60.0
    Wind speeds entered as meters/second

    Ground-level release
    Release height (m)                   =        .0
    Building Area (m^2)                  =    1155.0
    Effluent vertical velocity (m/s)     =       .00
    Vent or stack flow  (m^3/s)          =       .00
    Vent or stack radius (m)             =      6.72

    Direction .. intake to source (deg)  =       050
    Wind direction sector width (deg)    =        90
    Wind direction window (deg)          =   005 - 095
    Distance to intake (m)               =     135.0
    Intake height  (m)                   =       9.1
    Terrain elevation difference (m)     =        .0

    Output file names
      CHNSBWR.out
      CHNSBWR.jfd

    Minimum Wind Speed (m/s)             =        .5
    Surface roughness length (m)         =       .10
    Sector averaging constant            =       4.0

    Initial value of sigma y             =      3.12
    Initial value of sigma z             =       .00

    Expanded output for code testing not selected

    Total number of hours of data processed =  26307
    Hours of missing data                   =    416
    Hours direction in window               =   5965
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  19431

    DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL
    AVER. PER.        1          2          4          8         12         24         96        168        360        720
    UPPER LIM.   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03   1.00E-03
      LOW LIM.   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07   1.00E-07
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 ABOVE RANGE          0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
    IN RANGE       6460.      7712.      9395.     11745.     13756.     17618.     24509.     24994.     25169.     24910.
 BELOW RANGE          0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
        ZERO      19431.     18113.     16312.     13741.     11912.      7966.       696.       110.         0.         0.
  TOTAL X/Qs      25891.     25825.     25707.     25486.     25668.     25584.     25205.     25104.     25169.     24910.
  % NON ZERO       24.95      29.86      36.55      46.08      53.59      68.86      97.24      99.56     100.00     100.00

   95th PERCENTILE X/Q VALUES
               3.18E-04   3.11E-04   2.99E-04   2.75E-04   2.28E-04   1.73E-04   1.06E-04   8.93E-05   7.55E-05   6.55E-05

   95% X/Q for standard averaging intervals

   0 to 2 hours        3.18E-04
   2 to 8 hours        2.60E-04
   8 to 24 hours       1.22E-04
   1 to 4 days         8.31E-05
   4 to 30 days        5.94E-05

                         HOURLY VALUE RANGE
                        MAX X/Q                  MIN X/Q
       CENTERLINE       4.63E-04                 4.30E-05
       SECTOR-AVERAGE   2.90E-04                 2.69E-05

NORMAL PROGRAM COMPLETION
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ATTACHMENT D
EXCEL SPREADSHEET
HYDRAZINE - AUX BLDG ROOF INLET

	A	B	C	D	E	F	G
1	HYDRAZINE HYDRATE						
2							
3	CHEMICAL		N2H4				
4	IDLH (PPM)	IDLH	80				
5	ODOR THRESHOLD (PPM)	OT	3				
6	STORAGE QTY (GAL)	Q	375				
7	STORAGE PURITY (FRACTION)	QF	0.35				
8	SPECIFIC GRAVITY (GM/CC)	SG	1.008				
9	VAPOR PRESSURE (TORR-C-R-K)	VP	1.44E+01	25	536.67	298.15	
10	BOILING POINT (C-K-R)	TB	113.5	386.65	695.97		
11	MOLECULAR WT (GM/MOLE)	MB	32.05				
12	DIFFUSION COEFF (CM2/SEC)	D	0				
13							
14	MOLECULAR WT AIR (GM/MOLE)	MA	28.97				
15	MOL EN ATTR/BOLTZ CON AIR (K)	E/KA	78.6				
16	CHAR LENGTH AIR (A)	SIGA	3.711				
17	PRESSURE AIR (ATM-TORR-PSI)	PA	1	760	14.696		
18	TEMPERATURE AIR (C-K-R)	TA	30	303.15	545.67		
19	MASS DENSITY AIR (GM/CC)	RHOA	1.20E-03				
20	VISCOSITY OF AIR(G/CM-S)	MU	1.83E-04				
21	R(TORR-CM3/GMOLE-K)	R	6.24E+04				
22							
23	VOL-CR (CF)	VCR	234157				
24	Q-CR (CFM)	FCR	8300				
25	WIND VELOCITY(CM/SEC)	VW	100				
26	MAXIMUM TIME (MIN)	Tmax	2418.985	2418.985			
27	CONTROL ROOM FACTOR	CRF	1.00000		CRF = 1.-exp(-FCR*Tmax./VCR)		
28							
29	LEBAS MOLAL VOLUME						
30	C	14.8	0	0			
31	H	3.7	4	14.8			
32	O	7.4	0	0			
33	O IN METHYL ESTERS & ETHERS	9.1	0	0			
34	O IN ETHYL ESTERS & ETHERS	9.9	0	0			
35	O IN HIGHER ESTERS & ETHERS	11	0	0			
36	O IN ACIDS	12	0	0			
37	O JOINED TO S, P, N	8.3	0	0			
38	N DOUBLE BONDED	15.6	0	0			
39	N IN PRIMARY AMINES	10.5	2	21			
40	N IN SECONDARY AMINES	12	0	0			
41	BR	27	0	0			
42	CL	24.6	0	0			
43	F	8.7	0	0			
44	I	37	0	0			
45	S	25.6	0	0			
46	3-MEMBERED RING	-6.0	0	0			
47	4-MEMBERED RING	-8.5	0	0			
48	5-MEMBERED RING	-11.5	0	0			

	A	B	C	D	E	F	G
49	6-MEMBERED RING	-15.0	0	0			
50	NAPHTHALENE	-30.0	0	0			
51	ANTHRACENE	-47.5	0	0			
52	OTHER	0.0	0	0			
53	LEBAS MOLAL VOL VB' (CC/MOL)	VB'		35.8			
54							
55	DIFFUSION COEFFICIENT: METHOD OF WILKE AND LEE						
56	CHAR LENGTH B (A)	SIGB	1.18*VB'^1/3=				3.8890
57	CHAR LENGTH A-B (A)	SIGAB	(SIGA+SIGB)/2=				3.8000
58	MOL EN ATTR/BOLTZ CON B (K)	E/KB	1.15*(TB+273.15)=				444.6475
59	MOL EN ATTR/BOLTZ CON BA (K)	E/KAB	SQRT(E/KA*E/KB)=				186.9473
60	TSTAR	T*	TA/(E/KAB)=				1.6216
61	COLLISION INTEGRAL CONSTANT	A	1.06036				
62		B	0.15610				
63		C	0.19300				
64		D	0.47635				
65		E	1.03587				
66		F	1.52996				
67		G	1.76474				
68		H	3.89411				
69	COLLISION INTEGRAL	OMEGA	A/T*^B+C/e^(T*D)+E/e^(T*F)+G/e^(T*H)				1.1623E+00
70	B-PRIME	B'	0.00217-0.00050*SQRT(1/MA+1/MB) =				2.0418E-03
71	MOLECULAR WEIGHT	MR	(MA+MB)/(MA*MB)				6.5720E-02
72	DIFFUSION COEFF (CM2/SEC)	D	B'*TA^1.5*MR^0.5/(PA*SIGAB^2*OMEGA)=				1.6461E-01
73							1.6461E-01
74	VAPOR DENSITY (GM/CC)	RHOV	MB*14.696*0.01601846/(10.72*TVP)				1.3114E-03
75							
76	INITIAL MASS (GM)	M0	Q*QF*SG*(3785.422 CC/GAL)				5.0081E+05
77	VOLUME (M3)	VO	Q*QF*(3.785422E-3 M3/GAL) =				4.9684E-01
78	SPILL RADIUS INITIAL (M)	RO	(V0/PI)^0.33333 =				5.4078E-01
79	SPILL AREA INITIAL (M2)	AO	PI*RO^2 =				9.1874E-01
80	SPILL AREA FINAL (M2)	AF	VO/0.01 =				4.9684E+01
81	DELTA SPILL AREA (M2/SEC)	DA	SQRT(4*PI*9.81*VO*(SG-RHOA)/SG))				7.8214E+00
82	TIME TO MAX AREA (SEC)	tA	(AF-AO)/DA =				6.2348E+00
83	CHARACTERISTIC LENGTH(CM)	L	SQRT(4*VO*1.E6/PI)				7.9536E+02
84							
85	VAPOR DENSITY INSIDE CONTROL ROOM - DIFFUSION IN STILL AIR						
86			TF	NSB	WH		
87	ADC (S/M3)	ADC	3.33E-04	1.06E-03	9.17E-05		
88	TIME(SEC)	T	1	10	6.2348	40	
89	AREA(M2)	A	MIN(PI*R0^2+T*DA,AF)				
90	VAPORIZATION RATE (GM/M2-S)	VR	VP*RHOV*10000/760*SQRT(D/PI/t)				
91	VAPOR DEN INSIDE CR(GM/M3)	VD	VR*ADC*A				
92	PPM INSIDE CR	PPM	(24500/MB)*VD				
93			TF				
94	CASES	T	ADC	A	VR	VD	PPM
95		1	3.33E-04	8.74E+00	5.69E-02	1.66E-04	1.27E-01
96		10	3.33E-04	4.97E+01	1.80E-02	2.98E-04	2.27E-01

	A	B	C	D	E	F	G
97		6.2348	3.33E-04	4.97E+01	2.28E-02	3.77E-04	2.88E-01
98		40.0000	3.33E-04	4.97E+01	8.99E-03	1.49E-04	1.14E-01
99			NSB				
100		1	1.06E-03	8.74E+00	5.69E-02	5.27E-04	4.03E-01
101		10	1.06E-03	4.97E+01	1.80E-02	9.47E-04	7.24E-01
102		6.2348	1.06E-03	4.97E+01	2.28E-02	1.20E-03	9.17E-01
103		40.0000	1.06E-03	4.97E+01	8.99E-03	4.74E-04	3.62E-01
104			WH				
105		1	9.17E-05	8.74E+00	5.69E-02	4.56E-05	3.48E-02
106		10	9.17E-05	4.97E+01	1.80E-02	8.19E-05	6.26E-02
107		6.2348	9.17E-05	4.97E+01	2.28E-02	1.04E-04	7.93E-02
108		40.0000	9.17E-05	4.97E+01	8.99E-03	4.10E-05	3.13E-02
109							
110	VAPOR DENSITY INSIDE CONTROL ROOM - FORCED CONVECTION						
111	REYNOLD NUMBER	RE	L*VW*RHOA/MU				5.2214E+05
112	SCHMIDT NUMBER	SC	MU/(D*RHOA)				9.2536E-01
113							
114	TURB MASS TRANS COEFF(CM/S)	HDT	0.037*(D/L)*RE^0.8*SC^0.33333				2.7997E-01
115	TURB EVAP RATE(G/M2-S)	VFT	HDT*MB*VP*1.E4/(R*TVP)				6.9451E-02
116	VAPOR DEN INSIDE CR(GM/M3)	VD	VFT*ADC*AF*CRF				
117	PPM INSIDE CR	PPM	(24500/MB)*VD				
118	CASES		ADC	VD	PPM		
119		TF	3.33E-04	1.15E-03	8.7[illegible]E-01		
120		NSB	1.06E-03	3.66E-03	2.80E+00		
121		WH	9.17E-05	3.16E-04	2.42E-01		
122							
123	LAM MASS TRANS COEFF(CM/S)	HDL	0.664*(D/L)*RE^0.5*SC^0.33333				9.6769E-02
124	LAM EVAP RATE(G/M2-S)	VFL	HDL*MB*VP*1.E4/(R*TVP)				2.4005E-02
125	VAPOR DEN INSIDE CR(GM/M3)	VD	VFL*ADC*AF*CRF				
126	PPM INSIDE CR	PPM	(24500/MB)*VD				
127	CASES		ADC	VD	PPM		
128		TF	3.33E-04	3.97E-04	3.04E-01		
129		NSB	1.06E-03	1.26E-03	9.66E-01		
130		WH	9.17E-05	1.09E-04	8.36E-02		
131						laminar	turbulent
132	Time to peak (sec) =	t=1/ER/.0001*SG				419908.6	145139.07
133	Time to peak (min) =					6998.48	2418.98
134	Time to peak (hr) =					116.64	40.32
135							
136	Turbulent Evaporation without Recirc	Inlow(cfm)	8300	8300	8300	8300	ADC
137	TF	Time(min)	20	2418.98	2448.98	2478.98	3.33E-04
138		PPM	0.45	0.88	0.30	0.10	
139	Turbulent Evaporation without Recirc	Inlow(cfm)	8300	8300	8300	8300	ADC
140	NSB	Time(min)	20	2418.98	2448.98	2478.98	1.06E-03
141		PPM	1.42	2.80	0.97	0.33	
142	Turbulent Evaporation without Recirc	Inlow(cfm)	8300	8300	8300	8300	ADC
143	WH	Time(min)	20	2418.98	2448.98	2478.98	9.17E-05
144		PPM	0.12	0.24	0.08	0.03	

	A	B	C	D	E	F	G
145							
146	Turbulent Evaporation with Recirc	Inlow(cfm)	8300	3000	3000	3000	ADC
147	TF	Time(min)	20	2418.98	2448.98	2478.98	3.33E-04
148		PPM	0.45	0.88	0.30	0.10	
149	Turbulent Evaporation with Recirc	Inlow(cfm)	8300	3000	3000	3000	ADC
150	NSB	Time(min)	20	2418.98	2448.98	2478.98	1.06E-03
151		PPM	1.42	2.80	0.97	0.33	
152	Turbulent Evaporation with Recirc	Inlow(cfm)	8300	3000	3000	3000	ADC
153	WH	Time(min)	20	2418.98	2448.98	2478.98	9.17E-05
154		PPM	0.12	0.24	0.08	0.03	

ATTACHMENT E
EXCEL SPREADSHEET
HYDRAZINE - WEST ROAD INLET

	A	B	C	D	E	F	G
1	HYDRAZINE HYDRATE						
2							
3	CHEMICAL		N2H4				
4	IDLH (PPM)	IDLH	80				
5	ODOR THRESHOLD (PPM)	OT	3				
6	STORAGE QTY (GAL)	Q	375				
7	STORAGE PURITY (FRACTION)	QF	0.35				
8	SPECIFIC GRAVITY (GM/CC)	SG	1.008				
9	VAPOR PRESSURE (TORR-C-R-K)	VP	1.44E+01	25	536.67	298.15	
10	BOILING POINT (C-K-R)	TB	113.5	386.65	695.97		
11	MOLECULAR WT (GM/MOLE)	MB	32.05				
12	DIFFUSION COEFF (CM2/SEC)	D	0				
13							
14	MOLECULAR WT AIR (GM/MOLE)	MA	28.97				
15	MOL EN ATTR/BOLTZ CON AIR (K)	E/KA	78.6				
16	CHAR LENGTH AIR (A)	SIGA	3.711				
17	PRESSURE AIR (ATM-TORR-PSI)	PA	1	760	14.696		
18	TEMPERATURE AIR (C-K-R)	TA	30	303.15	545.67		
19	MASS DENSITY AIR (GM/CC)	RHOA	1.20E-03				
20	VISCOSITY OF AIR(G/CM-S)	MU	1.83E-04				
21	R(TORR-CM3/GMOLE-K)	R	6.24E+04				
22							
23	VOL-CR (CF)	VCR	234157				
24	Q-CR (CFM)	FCR	3000				
25	WIND VELOCITY(CM/SEC)	VW	100				
26	MAXIMUM TIME (MIN)	Tmax	2418.985	2418.985			
27	CONTROL ROOM FACTOR	CRF	1.00000		CRF = 1.-exp(-FCR*Tmax./VCR)		
28							
29	LEBAS MOLAL VOLUME						
30	C	14.8	0	0			
31	H	3.7	4	14.8			
32	O	7.4	0	0			
33	O IN METHYL ESTERS & ETHERS	9.1	0	0			
34	O IN ETHYL ESTERS & ETHERS	9.9	0	0			
35	O IN HIGHER ESTERS & ETHERS	11	0	0			
36	O IN ACIDS	12	0	0			
37	O JOINED TO S, P, N	8.3	0	0			
38	N DOUBLE BONDED	15.6	0	0			
39	N IN PRIMARY AMINES	10.5	2	21			
40	N IN SECONDARY AMINES	12	0	0			
41	BR	27	0	0			
42	CL	24.6	0	0			
43	F	8.7	0	0			
44	I	37	0	0			
45	S	25.6	0	0			
46	3-MEMBERED RING	-6.0	0	0			
47	4-MEMBERED RING	-8.5	0	0			
48	5-MEMBERED RING	-11.5	0	0			

	A	B	C	D	E	F	G
49	6-MEMBERED RING	-15.0	0	0			
50	NAPHTHALENE	-30.0	0	0			
51	ANTHRACENE	-47.5	0	0			
52	OTHER	0.0	0	0			
53	LEBAS MOLAL VOL VB' (CC/MOL)	VB'		35.8			
54							
55	DIFFUSION COEFFICIENT: METHOD OF WILKE AND LEE						
56	CHAR LENGTH B (A)	SIGB	1.18*VB'^1/3=				3.8890
57	CHAR LENGTH A-B (A)	SIGAB	(SIGA+SIGB)/2=				3.8000
58	MOL EN ATTR/BOLTZ CON B (K)	E/KB	1.15*(TB+273.15)=				444.6475
59	MOL EN ATTR/BOLTZ CON BA (K)	E/KAB	SQRT(E/KA*E/KB)=				186.9473
60	TSTAR	T*	TA/(E/KAB)=				1.6216
61	COLLISION INTEGRAL CONSTANT	A	1.06036				
62		B	0.15610				
63		C	0.19300				
64		D	0.47635				
65		E	1.03587				
66		F	1.52996				
67		G	1.76474				
8		H	3.89411				
69	COLLISION INTEGRAL	OMEGA	A/T*^B+C/e^(T*D)+E/e^(T*F)+G/e^(T*H)				1.1623E+00
70	B-PRIME	B'	0.00217-0.00050*SQRT(1/MA+1/MB) =				2.0418E-03
71	MOLECULAR WEIGHT	MR	(MA+MB)/(MA*MB)				6.5720E-02
72	DIFFUSION COEFF (CM2/SEC)	D	B'*TA^1.5*MR^0.5/(PA*SIGAB^2*OMEGA)=				1.6461E-01
73							1.6461E-01
74	VAPOR DENSITY (GM/CC)	RHOV	MB*14.696*0.01601846/(10.72*TVP)				1.3114E-03
75							
76	INITIAL MASS (GM)	M0	Q*QF*SG*(3785.422 CC/GAL)				5.0081E+05
77	VOLUME (M3)	VO	Q*QF*(3.785422E-3 M3/GAL) =				4.9684E-01
78	SPILL RADIUS INITIAL (M)	RO	(V0/PI)^0.33333 =				5.4078E-01
79	SPILL AREA INITIAL (M2)	AO	PI*RO^2 =				9.1874E-01
80	SPILL AREA FINAL (M2)	AF	VO/0.01 =				4.9684E+01
81	DELTA SPILL AREA (M2/SEC)	DA	SQRT(4*PI*9.81*VO*(SG-RHOA)/SG))				7.8214E+00
82	TIME TO MAX AREA (SEC)	tA	(AF-AO)/DA =				6.2348E+00
83	CHARACTERISTIC LENGTH(CM)	L	SQRT(4*VO*1.E6/PI)				7.9536E+02
84							
85	VAPOR DENSITY INSIDE CONTROL ROOM - DIFFUSION IN STILL AIR						
86			TF	NSB	WH		
87	ADC (S/M3)	ADC	2.15E-04	3.18E-04	1.10E-04		
88	TIME(SEC)	T	1	10	6.2348	40	
89	AREA(M2)	A	MIN(PI*R0^2+T*DA,AF)				
90	VAPORIZATION RATE (GM/M2-S)	VR	VP*RHOV*10000/760*SQRT(D/PI/t)				
91	VAPOR DEN INSIDE CR(GM/M3)	VD	VR*ADC*A				
92	PPM INSIDE CR	PPM	(24500/MB)*VD				
93			TF				
94	CASES	T	ADC	A	VR	VD	PPM
95		1	2.15E-04	8.74E+00	5.69E-02	1.07E-04	8.17E-02
96		10	2.15E-04	4.97E+01	1.80E-02	1.92E-04	1.47E-01

	A	B	C	D	E	F	G
97		6.2348	2.15E-04	4.97E+01	2.28E-02	2.43E-04	1.86E-01
98		40.0000	2.15E-04	4.97E+01	8.99E-03	9.61E-05	7.34E-02
99			NSB				
100		1	3.18E-04	8.74E+00	5.69E-02	1.58E-04	1.21E-01
101		10	3.18E-04	4.97E+01	1.80E-02	2.84E-04	2.17E-01
102		6.2348	3.18E-04	4.97E+01	2.28E-02	3.60E-04	2.75E-01
103		40.0000	3.18E-04	4.97E+01	8.99E-03	1.42E-04	1.09E-01
104			WH				
105		1	1.10E-04	8.74E+00	5.69E-02	5.47E-05	4.18E-02
106		10	1.10E-04	4.97E+01	1.80E-02	9.83E-05	7.51E-02
107		6.2348	1.10E-04	4.97E+01	2.28E-02	1.24E-04	9.52E-02
108		40.0000	1.10E-04	4.97E+01	8.99E-03	4.92E-05	3.76E-02
109							
110	VAPOR DENSITY INSIDE CONTROL ROOM - FORCED CONVECTION						
111	REYNOLD NUMBER	RE	L*VW*RHOA/MU				5.2214E+05
112	SCHMIDT NUMBER	SC	MU/(D*RHOA)				9.2536E-01
113							
114	TURB MASS TRANS COEFF(CM/S)	HDT	0.037*(D/L)*RE^0.8*SC^0.33333				2.7997E-01
115	TURB EVAP RATE(G/M2-S)	VFT	HDT*MB*VP*1.E4/(R*TVP)				6.9451E-02
116	VAPOR DEN INSIDE CR(GM/M3)	VD	VFT*ADC*AF*CRF				
117	PPM INSIDE CR	PPM	(24500/MB)*VD				
118	CASES		ADC	VD	PPM		
119		TF	2.15E-04	7.42E-04	5.67E-01		
120		NSB	3.18E-04	1.10E-03	8.39E-01		
121		WH	1.10E-04	3.80E-04	2.90E-01		
122							
123	LAM MASS TRANS COEFF(CM/S)	HDL	0.664*(D/L)*RE^0.5*SC^0.33333				9.6769E-02
124	LAM EVAP RATE(G/M2-S)	VFL	HDL*MB*VP*1.E4/(R*TVP)				2.4005E-02
125	VAPOR DEN INSIDE CR(GM/M3)	VD	VFL*ADC*AF*CRF				
126	PPM INSIDE CR	PPM	(24500/MB)*VD				
127	CASES		ADC	VD	PPM		
128		TF	2.15E-04	2.56E-04	1.96E-01		
129		NSB	3.18E-04	3.79E-04	2.90E-01		
130		WH	1.10E-04	1.31E-04	1.00E-01		
131						laminar	turbulent
132	Time to peak (sec) =	t=1/ER/.0001*SG				419908.6	145139.07
133	Time to peak (min) =					6998.48	2418.98
134	Time to peak (hr) =					116.64	40.32
135							
136	Turbulent Evaporation with Recirc	Inlow(cfm)	3000	3000	3000	3000	ADC
137	TF	Time(min)	20	2418.98	2448.98	2478.98	2.15E-04
138		PPM	0.13	0.57	0.39	0	
139	Turbuient Evaporation with Recirc	Inlow(cfm)	3000	3000	3000	3000	ADC
140	NSB	Time(min)	20	2418.98	2448.98	2478.98	3.18E-04
141		PPM	0.19	0.84	0.57	0.39	
142	Turbulent Evaporation with Recirc	Inlow(cfm)	3000	3000	3000	3000	ADC
143	WH	Time(min)	20	2418.98	2448.98	2478.98	1.10E-04
144		PPM	0.07	0.29	0.20	0.13	

ATTACHMENT F
CORRESPONDENCE

BECHTEL POWER CORPORATION

TELEPHONE CALL

By: Jamal K. Ghaben **Of:** NOPS

To: Evelyn Eshelman **Of:** CCNPP - Chemistry

Date: 11/3/94 **Time:** 2:00 PM

Subject: CCNPP Control Room Habitability, Inventory of Chemicals

Route/Copy
R. Patel [illegible] 11/5
S. Levine sal 11/7
D. Patton

Job No: 11865

File: 774

I contacted Evelyn to establish the amounts of chemicals currently in use, and the chemicals (ETA) to be stored in the future at CCNPP. The following input was provided:

- Hydrazine is procured in concentrations of 35% in a 350 gallon tote bins. This chemical will be located in Warehouse No. 3, the Tank Farm, and the North service Building.

- Morpholine is procured in concentrations of 99% in a 280 gallon tote bins filled only with 170 gallons of Morpholine. A total of eight totes four of which are full on site at a time. This chemical will be located in Warehouse No. 3, the Tank Farm. and the North service Building.

- Ammonia is purchased in concentrations of 28-30% and diluted to 11% in the tank. This chemical will be located in Warehouse No. 3, the Tank Farm.

- ETA will be procured in concentrations of 85% in a 350 gallon totes. This chemical will be located in Warehouse No. 3, the Tank Farm, and the North service Building.

The above information will be utilized in performing the analysis currently underway for the CCNPP Control Room Habitability by considering a chemical spill due failure of the largest container for each chemical.

Jamal

CA04542 REV 0
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Ecolochem, Inc.

Ecolochem, Inc.
4545 Patent Road
Norfolk, Virginia
23502

Phone: (804) 855-9000
Fax: (804) 855-1478

05-01-96

Wednesday, April 24, 1996

Mr. Jack Bills
Baltimore Gas and Electric Co.
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway, Rte 2
Lusby, MD 20657
Phone: (410) 495-2434
FAX: (410) 495-6628

T G.E. Gryczkowski,

Request you provide a control room habitability evaluation for the Hydrochloric Acid as described in this letter. The hydrazine is already in use with the current water treatment vendor.

Plant Chemistry
J.M. Bill
Ext. 2431

Dear Jack,

Attached are MSDS sheets for the chemicals and reagents that we plan to use at the Calvert Cliffs Plant. The bulk chemicals used in the water treatment process are hydrochloric acid and hydrazine. The other MSDS sheets are for silica, carbon dioxide, hydrazine, and dissolved oxygen test kit reagents.

We would like to store up to 1000 gallons of 20% by weight hydrochloric acid in two 500 gallon polyethylene tanks in separate polyethylene containment basins. This amounts to a maximum of 9200 pounds of acid solution of which 1800 pounds is hydrochloric acid. These chemicals would be stored underneath the RO trailer and surrounded by the trailer skirting. The acid solution would be drawn from the tank by suction to the metering pumps located inside the RO trailer. Should the acid line fail, the vacuum on the suction line would be lost and the acid would return by gravity to the storage tank. At 100 gallons per minute average product water flow rate, about 20 gallons of the acid solution would be consumed per day. The acid tanks would be refilled by hose from non-pressurized vessels on a delivery truck. A higher percentage of hydrochloric acid solution could be considered, but we prefer the 20% solution due to its low vapor pressure and fuming characteristics.

Hydrazine would be delivered in stainless steel tote bins, and would need a forklift to be changed out. The tote bins have a maximum volume of 375 gallons and we would only need one in service at a time. The solution in the tote bins is 35% by weight hydrazine and the total weight of hydrazine solution is 3210 pounds, of which 1125 pounds is hydrazine. The hydrazine solution will be drawn from the tote bin by suction in a manner similar to the acid system. At 100 gallons per minute average product water flow rate, about 1 gallon of hydrazine solution would be used per day. Due to the low volume of hydrazine used, we are trying to find out if hydrazine is available in smaller bins.

We are still researching the specifics on longer trailers to accommodate the space required for your instrument panel and silica analyzers. The design will be either a longer trailer or a separate enclosure. I will get back to you with the details as soon as they are available.

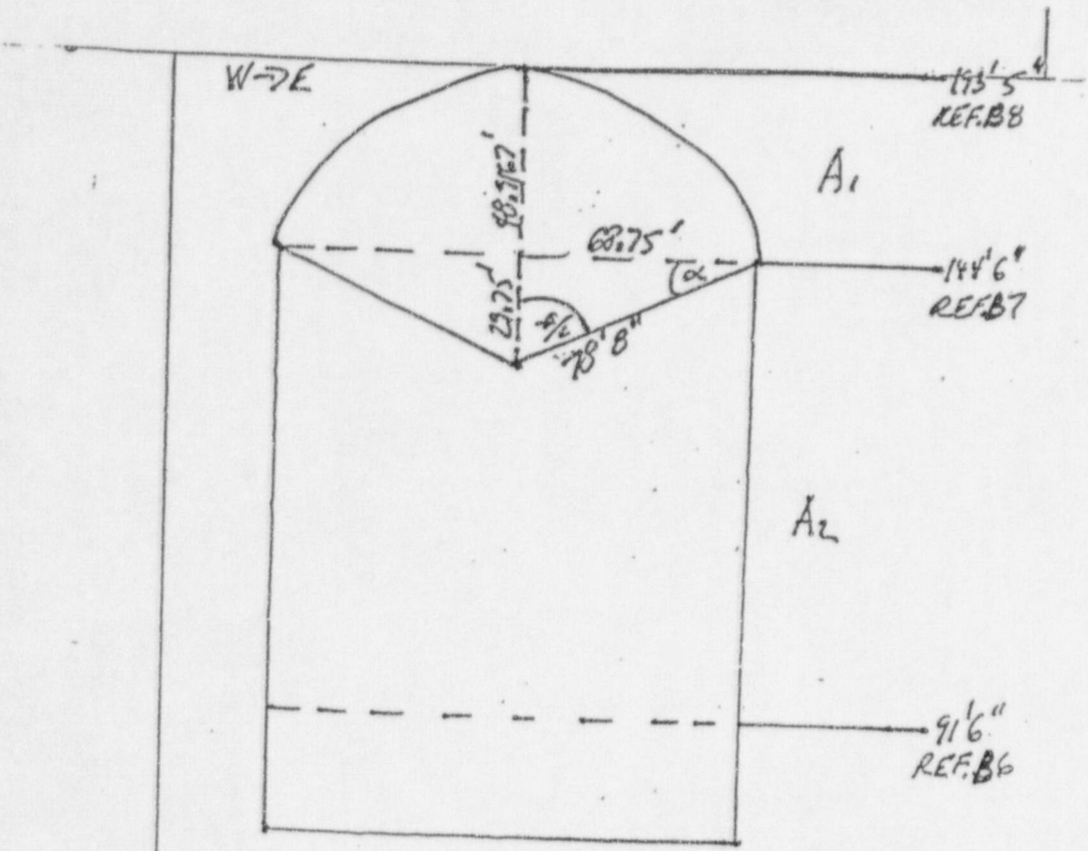
Please call me at (800) 446-8004 if you have questions.

Richard Hildebrand
Engineering Manager

Attachments - MSDS sheets for:

- Hydrazine (Olin)
- Hydrochloric acid (Olin)
- Activated Carbon (deoxygenation catalyst media) (Envirotrol)
- Anion ion exchange resin (IRA-402) (Rohm and Haas)
- Cation ion exchange resin (IR-122) (Rohm and Haas)
- Dissolved oxygen CHEM-et vacu-vials (Chemetrics)
- Dissolved oxygen CHEM-et ULR vacu-vials (Chemetrics)
- Hydrazine CHEM-et and hydrazine ULR CHEM-et vacu-vials (Chemetrics)
- Carbon dioxide titrets (Chemetrics)
- Carbon dioxide neutralizer solution (Chemetrics)
- Carbon dioxide activator solution (Chemetrics)
- Molybdate reagent for silica (Hach)
- Oxalic acid reagent for silica (Hach)
- Amino acid reagent for silica (Hach)
- Silica standard solution (Hach)

ATTACHMENT G
CROSS SECTIONAL AREAS



$R = 78.6667'$ REF.B7

$C = 137.5'$ REF.B7

$\alpha = \text{ARCTAN}(29.75/68.75)$
$= 23.3995^\circ$

$\theta = 133.2011^\circ = 2.3248\ r$

$h = 48.9167'$

$d = 29.75'$

$S = R\theta = 182.8841$

$A_1 = \frac{1}{2}(Rs - cd) = 5148.13\ \text{ft}^2$

$A_2 = (137.5)(144.5 - 91.5) = 7287.5\ \text{ft}^2$

$A_{CTMT} = 12435.63\ \text{ft}^2$

$A_{AB} = (\underset{\text{REF.B5}}{120'10"} - \underset{\text{REF.B6}}{91'6"}) \cdot (\underset{\text{REF.B4}}{66.1'}) = 1938.93\ \text{ft}^2$

$A_{TOT} = 2 * A_{CTMT} + A_{AB} = 26810.19\ \text{ft}^2$

TURBINE BUILDING: E→W

$A_{TB} = (\underset{\text{REF.B8}}{138.5833} - \underset{\text{REF.B6}}{91.5}) \cdot (\underset{\text{REF.B4}}{577'}) = 27167.06\ \text{ft}^2$

CONTAINMENT & TURBINE BUILDING: N→S & S→N

$A_{TB} = (\underset{\text{REF.B8}}{138.5833} - \underset{\text{REF.B6}}{91.5}) \cdot (\underset{\text{REF.B9}}{182.25'}) = 8580.93\ \text{ft}^2$

$A_{CTMT} = 12435.63\ \text{ft}^2$

$A_{TOTAL} = 21016.56\ \text{ft}^2$