ATTACHMENT 19, CALCULATION COVER SHEET

INITIATION (Control Doc Type - DCALC)

Page 1 of 45

DCALC No.: CA04554 Revision No.: 0

Vendor Calculation (Check one): ☐ Yes ☒ No

ESP ES19980640 Supp No.: 0 Rev. No.: 0

Responsible Group: NEY

Responsible Engineer: Gerard E. Gryczkowski

CALCULATION

ENGINEERING DISCIPLINE:

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

Title: 12500 GAL 100% SULFURIC ACID 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: NA

REVIEW AND APPROVAL:

Responsible Engineer: Gerard E. Gryczkowski / [signature] Date: 8/14/98

Independent Reviewer: I M Sommerville / [signature] Date: 9/1/98

Approval: J. A. Mihalcik / [signature] Date: 30 Sept 1998

2. LIST OF EFFECTIVE PAGES

Page	Latest Rev	Page	Latest Rev	Page	Latest Rev	Page	Latest Rev	Page	Latest Rev
001	0	002	0	003	0	004	0	005	0
006	0	007	0	008	0	009	0	010	0
011	0	012	0	013	0	014	0	015	0
016	0	017	0	018	0	019	0	020	0
021	0	022	0	023	0	024	0	025	0
026	0	027	0	028	0	029	0	030	0
031	0	032	0	033	0	034	0	035	0
036	0	037	0	038	0	039	0	040	0
041	0	042	0	043	0	044	0	045	0

3. REVIEWER COMMENTS

4. TABLE OF CONTENTS

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).

CCNPP proposes to use a 90% sulfuric acid solution, which will be stored in an 12900 gal tank at the tank farm. The chemical habitability of the control room after a chemical release involving 100% sulfuric acid 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 100% sulfuric acid solution can be stored in the 12900 gal storage tank at the tank farm 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 100% Sulfuric Acid Solution are as follows:

		Peak Concentration
Current Configuration	No Recirculation	2.50 ppb
	With Recirculation	2.50 ppb
Modified Configuration	With Recirculation	1.75 ppb
Toxicity Limit (IDLH)		20 ppm

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. Sulfuric acid will not pose a flammability or explosion hazard in the control room, since the substance is nonflammable.

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.

6. INPUT DATA

The following input data is incorporated into this work:

(01) Chemical data for 100% sulfuric acid:

CAS number	7664-93-9	Refs.5,9
Chemical formula	H_2SO_4	Refs.5,9
Toxicity Limit IDLH (ppm)	20.	Ref.5
Odor threshold (ppm)	0.25	Ref.5
Volume fraction	1.00	Assumed
Volume (gal)	29900	Refs.19,20
Specific gravity (gm/cc)	1.84	Refs.5,9
Vapor pressure (mm Hg) VP	0.0015@35°C	Ref.21
Boiling point (Degrees C) TB	290	Ref.9
Molecular weight (gm/mole) MB	98.08	Refs.5,9
Lower explosion limit (Vol%)	Non-flammable	Ref.5

(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-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): 39.42.

$r = SQRT(A/\pi)$

$= SQRT[(12900gal)*(3785.422cc/gal)/(1.cm)/\pi*(1.E-4m^2/cm^2)]$

$= 39.42$ m

(l) Direction to source (deg): 335 Refs.B12,B14

(m) Source window (deg): 090 Refs.B13-B14

(n) Distance from source to receptor (m): 163 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: CHTF2CR.OUT

(r) JFT file name: CHTF2CR.JFD

(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): 18.33

σ_y=r/2.15=39.42/2.15=18.33 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 to the Control Room:

0- 2 hrs	2.11E-04 sec/m3
2- 8 hrs	1.69E-04 sec/m3
8- 24 hrs	7.69E-05 sec/m3
24- 96 hrs	5.35E-05 sec/m3
96-720 hrs	4.36E-05 sec/m3

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

(08) The Tank Farm-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): 39.42

$r = SQRT(A/\pi)$

$= SQRT[(12900gal)*(3785.422cc/gal)/(1.cm)/\pi*(1.E\text{-}4m^2/cm^2)]$

$= 39.42$ m

(l) Direction to source (deg): 354 Refs.B12,B14

(m) Source window (deg):	090	Refs.B13-B14
(n) Distance from source to receptor (m):	201.37	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:	CHTF2WR.OUT	
(r) JFT file name:	CHTF2WR.JFD	
(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):	18.33	

σ_y=r/2.15=39.42/2.15=18.33 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 to the West Road Inlet:

0- 2 hrs	1.48E-04 sec/m3
2- 8 hrs	1.21E-04 sec/m3
8- 24 hrs	5.64E-05 sec/m3
24- 96 hrs	4.12E-05 sec/m3
96-720 hrs	3.30E-05 sec/m3

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

7. TECHNICAL ASSUMPTIONS

The following technical assumptions were utilized in this work:

(01) Per Refs.19-21, ≤ 90% Sulfuric Acid Solution is stored in the concentrated acid storage tank of 12900 gals capacity max. A 100% concentration will be conservatively assumed in this work.

(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 sulfuric acid solution, the 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 Sulfuric Acid.

(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.

(19) Plant Data Book, March 1975 (Att.F)

(20) ES199502500, MCR for Concentrated Sulfuric Acid Storage Tank Fill Connection, 7/17/95 (Att.F).

(21) "Onsite Accidental Release of Sulfuric Acid", Bechtel Calculation M-80-39, 1/19/81.

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

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

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

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))
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
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 100% sulfuric acid inside the control room for a chemical spill of 12900 gal in the tank farm is calculated via EXCEL spreadsheets captured in the following attachments using the methodologies of Section 9:

Attachment D: 100% Sulfuric Acid Solution
for Current Control Room Configuration

Attachment E: 100% Sulfuric Acid 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

CCNPP proposes to use a 90% sulfuric acid solution, which will be stored in an 12900 gal tank at the tank farm. The chemical habitability of the control room after a chemical release involving 100% sulfuric acid 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 100% sulfuric acid solution can be stored in the 12900 gal storage tank at the tank farm 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 100% Sulfuric Acid Solution are as follows:

		Peak Concentration
Current Configuration	No Recirculation	2.50 ppb
	With Recirculation	2.50 ppb
Modified Configuration	With Recirculation	1.75 ppb
Toxicity Limit (IDLH)		20 ppm

13. CONCLUSIONS

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. Sulfuric acid will not pose a flammability or explosion hazard in the control room, since the substance is nonflammable.

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
DATA FOR SULFURIC ACID

Common Synonyms	Oily liquid Colorless Odorless
Oil of vitriol Battery acid Fertilizer acid Chamber acid	Sinks and mixes violently with water. Irritating mist is produced.

AVOID CONTACT WITH LIQUID. Keep people away.
Wear goggles, self-contained breathing apparatus, and rubber overclothing.
Stop discharge if possible.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire	Not flammable. May cause fire on contact with combustibles. Flammable gas may be produced on contact with metals. POISONOUS GAS MAY BE PRODUCED IN FIRE. Wear goggles, self-contained breathing apparatus, and rubber overclothing. DO NOT USE WATER ON ADJACENT FIRES. Extinguish with dry chemical or carbon dioxide.
Exposure	CALL FOR MEDICAL AID. MIST Irritating to eyes, nose and throat. If inhaled, will cause coughing, difficult breathing, or loss of consciousness. Move to fresh air. IF IN EYES, hold eyelids open and flush with ple..ty of water. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID Will burn skin and eyes. Harmful if [illegible]llowed. Remove [illegible]minated clothing and shoes. Flush aff[illegible]ed areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victi.. 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-corrosive
Restrict access
Disperse and flush with care

2. LABEL

2.1 Category: Corrosive
2.2 Class: 8

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Sulfuric acid
3.2 Formula: H_2SO_4
3.3 IMO/UN Designation: 8.0/1830
3.4 DOT ID No.: 1830
3.5 CAS Registry No.: 7664-93-9

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless (pure) to dark brown
4.3 Odor: Odorless unless hot, then choking

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Safety shower; eyewash fountain; safety goggles; face shield; approved respirator (self-contained or air-line); rubber safety shoes; rubber apron.
5.2 Symptoms Following Exposure: Inhalation of vapor from hot, concentrated acid may injure lungs. Swallowing may cause severe injury or death. Contact with skin or eyes causes severe burns.
5.3 Treatment of Exposure: Call a doctor. INHALATION: observe victim for delayed pulmonary reaction. INGESTION: have victim drink water if possible; do NOT induce vomiting. EYES AND SKIN: wash with large amounts of water for at least 15 min.; do not use oils or ointments in eyes; treat skin burns.
5.4 Threshold Limit Value: 1 mg/m³
5.5 Short Term Inhalation Limits: 10 mg/m³ for 5 min.; 5 mg/m³ for 10 min.; 2 mg/m³ for 30 min.; 1 mg/m³ for 60 min.
5.6 Toxicity by Ingestion: No effects except those secondary to tissue damage.
5.7 Late Toxicity: None
5.8 Vapor (Gas) Irritant Characteristics: Vapors from hot acid (77-98%) cause moderate irritation of eyes and respiratory system. Effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: 77-98% acid causes severe second- and third-degree burns of skin on short contact and is very injurious to the eyes.
5.10 Odor Threshold: Greater than 1 mg/m³
5.11 IDLH Value: 80 mg/m³

6. FIRE HAZARDS

6.1 Flash Point: Not flammable
6.2 Flammable Limits in Air: Not flammable
6.3 Fire Extinguishing Agents: Not pertinent
6.4 Fire Extinguishing Agents Not to be Used: Water used on adjacent fires should be carefully handled.
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Not flammable
6.7 Ignition Temperature: Not flammable
6.8 Electrical Hazard: None
6.9 Burning Rate: Not flammable
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: Reacts violently with evolution of heat. Spattering occurs when water is added to the compound.
7.2 Reactivity with Common Materials: Extremely hazardous in contact with many materials, particularly metals and combustibles. Dilute acid reacts with most metals, releasing hydrogen which can form explosive mixtures with air in confined spaces.
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Dilute with water, then neutralize with lime, limestone, or soda ash.
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent

(Continued)

8. WATER POLLUTION

8.1 Aquatic Toxicity:
24.5 ppm/24 hr/bluegill/lethal/fresh water
42.5 ppm/48 hr/prawn/LC_{50}/salt water
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): None
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: CP; USP; Technical, at 33% to 98% (50° Be to 66° Be).
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-P-O

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Corrosive material
11.2 NAS Hazard Rating for Bulk Water Transportation:

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

11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	3
Flammability (Red)	0
Reactivity (Yellow)	2

W

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 98.08
12.3 Boiling Point at 1 atm: 644°F = 340°C = 613°K
12.4 Freezing Point: Not pertinent
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 1.84 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): Not pertinent
12.12 Latent Heat of Vaporization: Not pertinent
12.13 Heat of Combustion: Not pertinent
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: −418.0 Btu/lb = −232.2 cal/g = -9.715×10^5 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: Low

*Physical properties apply to concentrated (98%) acid unless otherwise stated. More dilute acid is more water-like.

7. CHEMICAL REACTIVITY (Continued)

7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 2

TOXICITY DATA WITH REFERENCE
eye-rbt 6 ppm/4H/32D MLD JPCAAC 10,17,60
mmo-omi 10 mmol/L MUREAV 39,149,77
dnd-hmn:lym 5700 ppb MUREAV 39,149,77
ihl-mus TCLo:32 ppm/24H (female 7-18D post):REP TJADAB 31,9B,85
ihl-mus TCLo:25 ppm/7H (female 6-15D post):TER FCTXAV 18,743,80
ihl-mus TCLo:500 ppm/5M/30W-I:ETA BJCAAI 21,606,67
ihl-hmn LCLo:1000 ppm/10M:PUL CTOXAO 5,198,72
ihl-hmn TCLo:3 ppm/5D:PUL TXAPA9 22,319,72
ihl-hmn TCLo:12 ppm/1H:PUL SAIGBL 14,449,72
ihl-rat LC50:2520 ppm/1H NTIS** AD-A148-952
ihl-dog TCLo:500 ppm/2H/21W-I JTEHD6 13,945,84
ihl-mus LC50:3000 ppm/30M JCTODH 4,236,77
ihl-gpg LCLo:1039 ppm/24H CBTIAE 10,281,39
ihl-frg LCLo:1 pph/15M HBAMAK 4,1396,35

CONSENSUS REPORTS: EPA Extremely Hazardous Substances List. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program.

OSHA PEL: TWA 2 ppm; STEL 5 ppm
ACGIH TLV: TWA 2 ppm; STEL 5 ppm
DFG MAK: 2 ppm (5 mg/m^3)
NIOSH REL: (Sulfur Dioxide) TWA 0.5 ppm
DOT CLASSIFICATION: 2.3; *Label:* Poison Gas

SAFETY PROFILE: A poison gas. Experimental reproductive effects. Human mutation data reported. Human systemic effects by inhalation: pulmonary vascular resistance, respiratory depression, and other pulmonary changes. Questionable carcinogen with experimental tumorigenic and teratogenic data. It chiefly affects the upper respiratory tract and the bronchi. It may cause edema of the lungs or glottis, and can produce respiratory paralysis. A corrosive irritant to eyes, skin, and mucous membranes. This material is so irritating that it provides its own warning of toxic concentration. Levels of 400–500 ppm are immediately dangerous to life. Its toxicity is comparable to that of hydrogen chloride. However, less than fatal concentration can be borne for fair periods of time with no apparent permanent damage. It is a common air contaminant.

A nonflammable gas. It reacts violently with acrolein, Al, $CsHC_2$, Cs_2O, chlorates, ClF_3, Cr, FeO, F_2, Mn, KHC_2, $KClO_3$, Rb_2C_2, Na, Na_2C_2, SnO, diamminolithiumacetylene carbide. Will react with water or steam to produce toxic and corrosive fumes. Incompatible with halogens or interhalogens, lithium nitrate, metal acetylides, metal oxides, metals, polymeric tubing, potassium chlorate, sodium hydride.

For occupational chemical analysis use OSHA: #ID-107 or NIOSH: Sulfur Dioxide, 6004.

SOI000 CAS:2551-62-4 HR: 1
SULFUR HEXAFLUORIDE
DOT: UN 1080
mf: F_6S mw: 146.06

PROP: Colorless, odorless gas of high chemical stability and inertness. Non flammable. White sublimable solid at low temps. Stable to H_2O and to glass. Mp: −51° (subl @ −64°), vap d: 6.602, d (liquid): 1.67 @ −100°. Very insol in H_2O; slightly sol in EtOH.

SYNS: HEXAFLUORURE de SOUFRE (FRENCH) □ SULFUR FLUORIDE

TOXICITY DATA WITH REFERENCE
ivn-rbt LD50:5790 mg/kg TOLED5 1000(Sp 1),100,80

CONSENSUS REPORTS: Reported in EPA TSCA Inventory.

OSHA PEL: TWA 1000 ppm
ACGIH TLV: TWA 1000 ppm
DFG MAK: 1000 ppm (6000 mg/m^3)
DOT CLASSIFICATION: 2.2; *Label:* Nonflammable Gas

SAFETY PROFILE: This material is chemically inert in the pure state and is considered to be physiologically inert as well. However, as it is ordinarily obtainable, it can contain variable quantities of the low-sulfur fluorides. Some of these are toxic, very reactive chemically, and corrosive in nature. These materials can hydrolyze on contact with water to yield hydrogen fluoride, which is highly toxic and very corrosive. In high concentrations and when pure it may act as a simple asphyxiant. Incompatible with disilane. Vigorous reaction with disilane. May explode. When heated to decomposition it emits highly toxic fumes of F^- and SO_x.

SOI200 CAS:57670-85-6 HR: 2
SULFUR THIOCYANATE
mf: $C_2N_2S_3$ mw: 148.22

PROP: White crystals. Polymerizes on heating. Decomp by H_2O. Mp: 93°. Sol in Et_2O, $CHCl_3$ and C_6H_6.

SYN: DICYANOTRISULFIDE

TOXICITY DATA WITH REFERENCE
ipr-rat LD:>500 mg/kg NCNSA6 5,28,53

SAFETY PROFILE: Moderately toxic by intraperitoneal route. Decomposes explosively on storage at room temperature. When heated to decomposition it emits toxic fumes of SO_x and NO_x. See also THIOCYANATES.

S

SOI500 CAS:7664-93-9 HR: 3
SULFURIC ACID
DOT: UN 1830/UN 1832
mf: H_2O_4S mw: 98.08

PROP: Viscous, colorless oily liquid; odorless. Mp: 10.49°, d: 1.834, vap press: 1 mm @ 145.8°, bp: 290°, decomp @ 340°. Misc with water and alc (liberating great heat).

SYNS: ACIDE SULFURIQUE (FRENCH) □ ACIDO SOLFORICO (ITALIAN) □ BOV □ DIPPING ACID □ HYDROOT □ MATTING ACID (DOT) □ NORDHAUSEN ACID (DOT) □ OIL OF VITRIOL (DOT) □ SCHWEFELSAEURELOESUNGEN (GERMAN) □ SPENT SULFURIC ACID (DOT) □ SULPHURIC ACID □ VITRIOL BROWN OIL □ VITRIOL, OIL OF (DOT) □ ZWAVELZUUROPLOSSINGEN (DUTCH)

TOXICITY DATA WITH REFERENCE
eye-rbt 1380 µg SEV AJOPAA 29,1363,46
eye-rbt 100 mg rns SEV TXCYAC 23,281,82
ihl-rbt TCLo:20 mg/m^3/7H (female 6-18D post):TER JESEDU 13,251,79
ihl-hmn TCLo:3 mg/m^3/24W BJIMAG 18,63,61
unr-man LDLo:135 mg/kg 85DCAI 2,73,70

CA04554 REV 0
PAGE 25

orl-rat LD50:2140 mg/kg AIHAAP 30,470,69
ihl-rat LC50:510 mg/m^3/2H 85GMAT -,107,82
ihl-mus LC50:320 mg/m^3/2H 85GMAT -,107,82
ihl-rat TCLo:784 $\mu g/m^3$/24H/84D-C GISAAA 38(3),6,73

CONSENSUS REPORTS: Reported in EPA TSCA Inventory.

OSHA PEL: TWA 1 mg/m^3
ACGIH TLV: TWA 1 mg/m^3; STEL 3 ppm
DFG MAK: 1 mg/m^3
NIOSH REL: (Sulfuric Acid) TWA 1 mg/m^3
DOT CLASSIFICATION: 8; *Label:* Corrosive

SAFETY PROFILE: Human poison by unspecified route. Experimental poison by inhalation. Moderately toxic by ingestion. A severe eye irritant. Extremely irritating, corrosive, and toxic to tissue, resulting in rapid destruction of tissue, causing severe burns. If much of the skin is involved, exposure is accompanied by shock, collapse, and symptoms similar to those seen in severe burns. Repeated contact with dilute solutions can cause a dermatitis, and repeated or prolonged inhalation of a mist of sulfuric acid can cause inflammation of the upper respiratory tract, leading to chronic bronchitis. Sensitivity to sulfuric acid or its mists or vapors varies with individuals. Normally 0.125–0.50 ppm may be mildly annoying, 1.5–2.5 ppm can be definitely unpleasant, and 10–20 ppm is unbearable. Workers exposed to low concentrations of the vapor gradually lose their sensitivity to its irritating action. Inhalation of concentrated vapor or mists from hot acid or oleum can cause rapid loss of consciousness with serious damage to lung tissue. Severe exposure may cause a chemical pneumonitis; erosion of the teeth due to exposure to strong acid fumes has been recognized in industry. An experimental teratogen.

This is a very powerful acidic oxidizer that can ignite or explode on contact with many materials, e.g., acetic acid, acetone cyanhydrin, (acetone + HNO_3), (acetone + $K_2Cr_2O_7$), acetonitrile, acrolein, acrylonitrile, (acrylonitrile + H_2O), (alcohols + H_2O_2), allyl alcohol, allyl chloride, NH_4OH, 2-amino ethanol, NH_4, triperchromate, aniline, (bromates + metals), BrF_5, n-butyraldehyde, carbides, $CoHC_2$, chlorates, (metals + chlorates), ClF_3, chlorosulfonic acid, Cu_3N, diisobutylene, (dimethyl benzylcarbinol + H_2O_2), epichlorohydrin, ethylene cyanhydrin, ethylene diamine, ethylene glycol, ethylene imine, fulminates, HCl, H_2, IF_7, (indene + HNO_3), Fe, isoprene, Li_6Si_2, Hg_3N_2, mesityl oxide, metals, (HNO_3 + glycerides), p-nitrotoluene, perchlorates, $HClO_4$, (C_6H_6 + permanganates), pentasilver trihydroxydiamino phosphate, (1-phenyl-2-methyl propyl alcohol + H_2O_2), P, $P(OCN)_3$, picrates, potassium-tert-butoxide, $KClO_3$, $KMnO_4$, ($KMnO_4$ + KCl), ($KMnO_4$ + H_2O), β-propiolactone, $RbHC_2$, propylene oxide, pyridine, Na, Na_2CO_3, NaOH, steel, styrene monomer, water, vinyl acetate, (HNO_3 + toluene). When heated it emits highly toxic fumes; will react with water or steam to produce heat; can react with oxidizing or reducing materials. When heated to decomposition it emits toxic fumes of SO_x. See also SULFATES.

For occupational chemical analysis use OSHA: #ID-113 or NIOSH: Acids, inorganic, 7903.

SOI510 **HR: 3**
SULFURIC ACID, aromatic

PROP: Clear, reddish-brown liquid; peculiar aromatic odor; pleasant acid taste when diluted.

SYN: ELIXIR of VITRIOL

SAFETY PROFILE: Corrosive. Flammable when exposed to heat or flame. Explosive in the form of vapor (ethyl alcohol) when exposed to heat or flame. When heated to decomposition it emits toxic fumes of SO_x. See also ETHYL ALCOHOL and SULFURIC ACID.

SOI520 **CAS:8014-95-7** **HR: 3**
SULFURIC ACID, fuming
DOT: NA 1831
mf: $H_2O_4S{\cdot}O_3S$ mw: 178.14

PROP: Heavy, fuming, yellow liquid. H_2SO_4 + up to 80% SO_3. A solution of sulfuric anhydride (sulfur trioxide) in anhydrous sulfuric acid (NTIS** PB233-098).

SYNS: DISULPHURIC ACID □ DITHIONIC ACID □ FUMING SULFURIC ACID □ OLEUM □ PYROSULPHURIC ACID □ SULFURIC ACID, fuming > or =30% free sulfur trioxide (DOT) □ SULFURIC ACID, fuming <30% free sulfur trioxide (DOT) □ SULFURIC ACID MIXTURE with SULFUR TRIOXIDE

TOXICITY DATA WITH REFERENCE
ihl-rat LC50:347 ppm/1H TXAPA9 42,417,77

CONSENSUS REPORTS: IARC Cancer Review: Group 1 IMEMDT 54,41,92; Human Sufficient Evidence IMEMDT 54,41,92.

NIOSH REL: TWA 1 mg/m^3
DOT CLASSIFICATION: 8; *Label:* Corrosive; DOT Class: 8; *Label:* Corrosive, Poison

SAFETY PROFILE: Confirmed human carcinogen. A poison. Moderately toxic by inhalation. A corrosive irritant to skin, eyes, and mucous membranes. A very dangerous fire hazard by chemical reaction with reducing agents and carbohydrates. A severe explosion hazard by chemical reaction with acetic acid, acetic anhydride, acetonitrile, acrolein, acrylic acid, acrylonitrile, allyl alcohol, allyl chloride, 2-amino ethanol, NH_4OH, aniline, cresol, n-butyraldehyde, cumene, dichloroethyl ether, diethylene glycol monomethyl ether, diisobutylene, epichlorohydrin, ethyl acetate, ethylene cyanohydrin, ethylene diamine, ethylene glycol, ethylene glycol monoethyl ether acetate, ethylene imine, glyoxal, HCl, HF, isoprene, isopropyl alcohol, mesityl oxide, methyl ethyl ketone, HNO_3, 2-nitropropane, β-propiolacetone, propylene oxide, pyridine, NaOH, styrene monomer, vinylidene chloride, sulfolane, vinyl acetate. Will react with water or steam to produce heat and toxic and corrosive fumes. Can react vigorously with reducing materials. When heated to decomposition it emits highly toxic fumes of SO_x. See also SULFUROUS ACID.

SOI530 **CAS:7664-93-9** **HR: 3**
SULFURIC ACID (mist)
mf: H_2O_4S mw: 98.08

PROP: The airborne form of sulfuric acid is an aerosol

ATTACHMENT B
ARCON96 FILES 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
                                 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
```



```
Program Run   8/21/1998  at  07:44:10

 ******* 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)                =     39.42

    Direction .. intake to source (deg)  =      335
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =    290 - 020
    Distance to intake (m)               =      163.0
    Intake height  (m)                   =       15.6
    Terrain elevation difference (m)     =         .0

    Output file names
      CHTF2CR.out
      CHTF2CR.jfd

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

    Initial value of sigma y                =     18.33
    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               =   7292
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  18104

    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	7787.	9277.	11183.	13638.	15683.	19595.	24932.	25103.	25169.	24910.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	18104.	16548.	14524.	11848.	9985.	5989.	273.	1.	0.	0.
TOTAL X/Qs	25891.	25825.	25707.	25486.	25668.	25584.	25205.	25104.	25169.	24910.
% NON ZERO	30.08	35.92	43.50	53.51	61.10	76.59	98.92	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

2.11E-04	2.04E-04	1.95E-04	1.79E-04	1.47E-04	1.11E-04	6.79E-05	6.00E-05	5.22E-05	4.68E-05

95% X/Q for standard averaging intervals

0 to 2 hours	2.11E-04
2 to 8 hours	1.69E-04
8 to 24 hours	7.69E-05
1 to 4 days	5.35E-05
4 to 30 days	4.36E-05

CA04554 REV 0
PAGE 28

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	2.75E-04	2.39E-05
SECTOR-AVERAGE	1.72E-04	1.50E-05

NORMAL PROGRAM COMPLETION

ATTACHMENT C
ARCON96 FILES FOR WEST ROAD INLET PLENUM

Program Title: ARCON96.

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

CA04554 REV 0
PAGE 30

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
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Code Documentation: NUREG/CR-6331 Rev. 1

Program Run 8/21/1998 at 07:44:37

```
******* 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)               =     39.42

    Direction .. intake to source (deg)    =      354
    Wind direction sector width (deg)      =       90
    Wind direction window (deg)            =   309 - 039
    Distance to intake (m)                 =     201.4
    Intake height  (m)                     =       9.1
    Terrain elevation difference (m)       =        .0

    Output file names
      CHTF2WR.out
      CHTF2WR.jfd

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

    Initial value of sigma y               =     18.33
    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

1.48E-04 1.44E-04 1.39E-04 1.28E-04 1.06E-04 8.01E-05 5.10E-05 4.49E-05 3.92E-05 3.54E-05

95% X/Q for standard averaging intervals

0 to 2 hours	1.48E-04
2 to 8 hours	1.21E-04
8 to 24 hours	5.64E-05
1 to 4 days	4.12E-05
4 to 30 days	3.30E-05

CA04554 REV 0
PAGE 31

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	1.98E-04	1.73E-05
SECTOR-AVERAGE	1.24E-04	1.08E-05

NORMAL PROGRAM COMPLETION

ATTACHMENT D
EXCEL SPREADSHEET
SULFURIC ACID - AUX BLDG ROOF INLET

	A	B	C	D	E	F	G
1	SULFURIC ACID						
2							
3	CHEMICAL		H2SO4				
4	IDLH (PPM)	IDLH	20				
5	ODOR THRESHOLD (PPM)	OT	0.25				
6	STORAGE QTY (GAL)	Q	12900				
7	STORAGE PURITY (FRACTION)	QF	1.00				
8	SPECIFIC GRAVITY (GM/CC)	SG	1.84				
9	VAPOR PRESSURE (TORR-C-R-K)	VP	1.50E-03	35	554.67	308.15	
10	BOILING POINT (C-K-R)	TB	290	563.15	1013.67		
11	MOLECULAR WT (GM/MOLE)	MB	98.08				
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	32028954	32028954			
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	2	7.4			
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	2	24			
37	O JOINED TO S, P, N	8.3	2	16.6			
38	N DOUBLE BONDED	15.6	0	0			
39	N IN PRIMARY AMINES	10.5	0	0			
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	1	25.6			
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'		73.6			
54							
55	DIFFUSION COEFFICIENT: METHOD OF WILKE AND LEE						
56	CHAR LENGTH B (A)	SIGB	1.18*VB'^1/3=				4.9451
57	CHAR LENGTH A-B (A)	SIGAB	(SIGA+SIGB)/2=				4.3280
58	MOL EN ATTR/BOLTZ CON B (K)	E/KB	1.15*(TB+273.15)=				647.6225
59	MOL EN ATTR/BOLTZ CON BA (K)	E/KAB	SQRT(E/KA*E/KB)=				225.6172
60	TSTAR	T*	TA/(E/KAB)=				1.3436
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)				1.2564E+00
70	B-PRIME	B'	0.00217-0.00050*SQRT(1/MA+1/MB) =				2.0643E-03
71	MOLECULAR WEIGHT	MR	(MA+MB)/(MA*MB)				4.4714E-02
72	DIFFUSION COEFF (CM2/SEC)	D	B'*TA^1.5*MR^0.5/(PA*SIGAB^2*OMEGA)=				9.7899E-02
73							9.7899E-02
74	VAPOR DENSITY (GM/CC)	RHOV	MB*14.696*0.01601846/(10.72*TVP)				3.8830E-03
75							
76	INITIAL MASS (GM)	M0	Q*QF*SG*(3785.422 CC/GAL)				8.9851E+07
77	VOLUME (M3)	VO	Q*QF*(3.785422E-3 M3/GAL) =				4.8832E+01
78	SPILL RADIUS INITIAL (M)	RO	(V0/PI)^0.33333 =				2.4957E+00
79	SPILL AREA INITIAL (M2)	AO	PI*RO^2 =				1.9567E+01
80	SPILL AREA FINAL (M2)	AF	VO/0.01 =				4.8832E+03
81	DELTA SPILL AREA (M2/SEC)	DA	SQRT(4*PI*9.81*VO*(SG-RHOA)/SG))				7.7562E+01
82	TIME TO MAX AREA (SEC)	tA	(AF-AO)/DA =				6.2706E+01
83	CHARACTERISTIC LENGTH(CM)	L	SQRT(4*VO*1.E6/PI)				7.8851E+03
84							
85	VAPOR DENSITY INSIDE CONTROL ROOM - DIFFUSION IN STILL AIR						
86			TF				
87	ADC (S/M3)	ADC	2.11E-04				
88	TIME(SEC)	T	1	10	62.7063	70	
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							
94	CASES	T	ADC	A	VR	VD	PPM
95		1	2.11E-04	9.71E+01	1.35E-05	2.77E-07	6.93E-05
96		10	2.11E-04	7.95E+02	4.28E-06	7.18E-07	1.79E-04

	A	B	C	D	E	F	G
97		62.7063	2.11E-04	4.88E+03	1.71E-06	1.76E-06	4.40E-04
98		70.0000	2.11E-04	4.88E+03	1.62E-06	1.67E-06	4.16E-04
99							
100	VAPOR DENSITY INSIDE CONTROL ROOM - FORCED CONVECTION						
101	REYNOLD NUMBER	RE	L*VW*RHOA/MU				5.1765E+06
102	SCHMIDT NUMBER	SC	MU/(D*RHOA)				1.5559E+00
103							
104	TURB MASS TRANS COEFF(CM/S)	HDT	0.037*(D/L)*RE^0.8*SC^0.33333				1.2514E-01
105	TURB EVAP RATE(G/M2-S)	VFT	HDT*MB*VP*1.E4/(R*TVP)				9.5747E-06
106	VAPOR DEN INSIDE CR(GM/M3)	VD	VFT*ADC*AF*CRF				
107	PPM INSIDE CR	PPM	(24500/MB)*VD				
108	CASES	ADC	VD	PPM			
109		2.11E-04	9.87E-06	2.46E-03			
110							
111	LAM MASS TRANS COEFF(CM/S)	HDL	0.664*(D/L)*RE^0.5*SC^0.33333				2.1735E-02
112	LAM EVAP RATE(G/M2-S)	VFL	HDL*MB*VP*1.E4/(R*TVP)				1.6630E-06
113	VAPOR DEN INSIDE CR(GM/M3)	VD	VFL*ADC*AF*CRF				
114	PPM INSIDE CR	PPM	(24500/MB)*VD				
115	CASES	ADC	VD	PPM			
116		2.11E-04	1.71E-06	4.28E-04			
117						laminar	turbulent
118	Time to peak (sec) =	t=1/ER/.0001*SG				1.11E+10	1.92E+09
119	Time to peak (min) =					1.84E+08	3.20E+07
120	Time to peak (hr) =					3.07E+06	5.34E+05
121							
122	Turbulent Evaporation without Recirc	Inlow(cfm)	8300	8300	8300	8300	ADC
123		Time(min)	2.00E+01	3.20E+07	3.20E+07	3.20E+07	2.11E-04
124		PPM	1.25E-03	2.46E-03	8.51E-04	2.94E-04	
125							
126	Turbulent Evaporation with Recirc	Inlow(cfm)	8300	3000	3000	3000	ADC
127		Time(min)	2.00E+01	3.20E+07	3.20E+07	3.20E+07	2.11E-04
128		PPM	1.25E-03	2.46E-03	1.68E-03	1.14E-03	

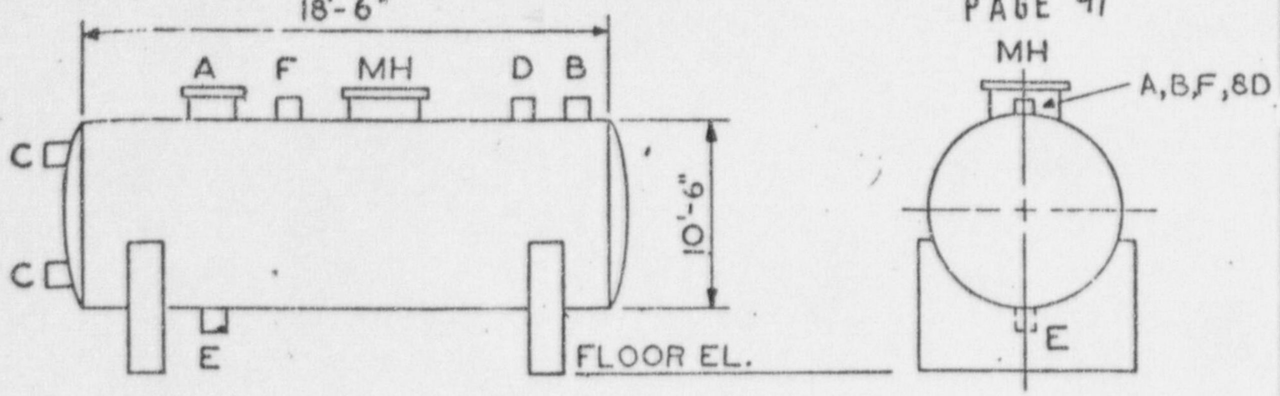
ATTACHMENT E
EXCEL SPREADSHEET
SULFURIC ACID - WEST ROAD INLET

	A	B	C	D	E	F	G
1	SULFURIC ACID						
2							
3	CHEMICAL		H2SO4				
4	IDLH (PPM)	IDLH	20				
5	ODOR THRESHOLD (PPM)	OT	0.25				
6	STORAGE QTY (GAL)	Q	12900				
7	STORAGE PURITY (FRACTION)	QF	1.00				
8	SPECIFIC GRAVITY (GM/CC)	SG	1.84				
9	VAPOR PRESSURE (TORR-C-R-K)	VP	1.50E-03	35	554.67	308.15	
10	BOILING POINT (C-K-R)	TB	290	563.15	1013.67		
11	MOLECULAR WT (GM/MOLE)	MB	98.08				
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	32028954	32028954			
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	2	7.4			
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	2	24			
37	O JOINED TO S, P, N	8.3	2	16.6			
38	N DOUBLE BONDED	15.6	0	0			
39	N IN PRIMARY AMINES	10.5	0	0			
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	1	25.6			
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'		73.6			
54							
55	DIFFUSION COEFFICIENT: METHOD OF WILKE AND LEE						
56	CHAR LENGTH B (A)	SIGB	1.18*VB'^1/3=				4.9451
57	CHAR LENGTH A-B (A)	SIGAB	(SIGA+SIGB)/2=				4.3280
58	MOL EN ATTR/BOLTZ CON B (K)	E/KB	1.15*(TB+273.15)=				647.6225
59	MOL EN ATTR/BOLTZ CON BA (K)	E/KAB	SQRT(E/KA*E/KB)=				225.6172
60	TSTAR	T*	TA/(E/KAB)=				1.3436
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)				1.2564E+00
70	B-PRIME	B'	0.00217-0.00050*SQRT(1/MA+1/MB) =				2.0643E-03
71	MOLECULAR WEIGHT	MR	(MA+MB)/(MA*MB)				4.4714E-02
72	DIFFUSION COEFF (CM2/SEC)	D	B'*TA^1.5*MR^0.5/(PA*SIGAB^2*OMEGA)=				9.7899E-02
73							9.7899E-02
74	VAPOR DENSITY (GM/CC)	RHOV	MB*14.696*0.01601846/(10.72*TVP)				3.8830E-03
75							
76	INITIAL MASS (GM)	M0	Q*QF*SG*(3785.422 CC/GAL)				8.9851E+07
77	VOLUME (M3)	VO	Q*QF*(3.785422E-3 M3/GAL) =				4.8832E+01
78	SPILL RADIUS INITIAL (M)	RO	(V0/PI)^0.33333 =				2.4957E+00
79	SPILL AREA INITIAL (M2)	AO	PI*RO^2 =				1.9567E+01
80	SPILL AREA FINAL (M2)	AF	VO/0.01 =				4.8832E+03
81	DELTA SPILL AREA (M2/SEC)	DA	SQRT(4*PI*9.81*VO*(SG-RHOA)/SG))				7.7562E+01
82	TIME TO MAX AREA (SEC)	tA	(AF-AO)/DA =				6.2706E+01
83	CHARACTERISTIC LENGTH(CM)	L	SQRT(4*VO*1.E6/PI)				7.8851E+03
84							
85	VAPOR DENSITY INSIDE CONTROL ROOM - DIFFUSION IN STILL AIR						
86			TF				
87	ADC (S/M3)	ADC	1.48E-04				
88	TIME(SEC)	T	1	10	62.7063	70	
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							
94	CASES	T	ADC	A	VR	VD	PPM
95		1	1.48E-04	9.71E+01	1.35E-05	1.94E-07	4.86E-05
96		10	1.48E-04	7.95E+02	4.28E-06	5.03E-07	1.26E-04

	A	B	C	D	E	F	G
97		62.7063	1.48E-04	4.88E+03	1.71E-06	1.23E-06	3.08E-04
98		70.0000	1.48E-04	4.88E+03	1.62E-06	1.17E-06	2.92E-04
99							
100	VAPOR DENSITY INSIDE CONTROL ROOM - FORCED CONVECTION						
101	REYNOLD NUMBER	RE	L*VW*RHOA/MU				5.1765E+06
102	SCHMIDT NUMBER	SC	MU/(D*RHOA)				1.5559E+00
103							
104	TURB MASS TRANS COEFF(CM/S)	HDT	0.037*(D/L)*RE^0.8*SC^0.33333				1.2514E-01
105	TURB EVAP RATE(G/M2-S)	VFT	HDT*MB*VP*1.E4/(R*TVP)				9.5747E-06
106	VAPOR DEN INSIDE CR(GM/M3)	VD	VFT*ADC*AF*CRF				
107	PPM INSIDE CR	PPM	(24500/MB)*VD				
108	CASES	ADC	VD	PPM			
109		1.48E-04	6.92E-06	1.73E-03			
110							
111	LAM MASS TRANS COEFF(CM/S)	HDL	0.664*(D/L)*RE^0.5*SC^0.33333				2.1735E-02
112	LAM EVAP RATE(G/M2-S)	VFL	HDL*MB*VP*1.E4/(R*TVP)				1.6630E-06
113	VAPOR DEN INSIDE CR(GM/M3)	VD	VFL*ADC*AF*CRF				
114	PPM INSIDE CR	PPM	(24500/MB)*VD				
115	CASES	ADC	VD	PPM			
116		1.48E-04	1.20E-06	3.00E-04			
117						laminar	turbulent
118	Time to peak (sec) =	t=1/ER/.0001*SG				1.11E+10	1.92E+09
119	Time to peak (min) =					1.84E+08	3.20E+07
120	Time to peak (hr) =					3.07E+06	5.34E+05
121							
122	Turbulent Evaporation with Recirc	Inlow(cfm)	3000	3000	3000	3000	ADC
123		Time(min)	2.00E+01	3.20E+07	3.20E+07	3.20E+07	1.48E-04
124		PPM	3.91E-04	1.73E-03	1.18E-03	8.01E-04	

ATTACHMENT F
TANK DATA SHEET AND ES199502500



ELEVATION

PLAN

(2) ONE (1) REQ'D CAPACITY 12900 GAL.

MK:"CONCENTRATED ACID STORAGE TANK NO. II"

NOZZLE SCHEDULE

MARK	QTY.	SIZE	SERVICE	REMARKS
A	1	20"	ACID PUMP	FLANGED
B	1	6"	FILL	SCH. 40 B.W.
C	2	1"	LEVEL GAUGE	150 # R.F.
D	1	4"	BREATHER&VENT	SCH. 40 B.W.
E	1	1"	DRAIN	SCH. 80 S.W.
MH	1	24"	MANHOLE	
F	1	1"	DRY AIR	SCH. 80 S.W.

NOZZLE AND BOSS LOCATIONS ARE SCHEMATIC ONLY. FINAL ARRANGEMENT WILL BE MARKED ON VENDOR'S DRAWINGS.

SHELL: MTL/THICKNESS	CARB. STL./PER CODE
INTERNALS (TRAYS ETC.)	
INSUL CLIPS?	
MANUFACTURER	Buffalo Tank
SERIAL NO	
WEIGHT: NET/FLOODED	
(PO NO) (REQ'N NO.)	
SPEC NO	6750-M-219
COST CODE	

OPERATING PRESS(PSIG)/TEMP(F)	
DESIGN PRESS(PSIG)/TEMP(F)	ATM/150
S.V. SETTING/HYDRO TEST PRESS	NONE/HYDRO LEAK TEST
CORROSION ALLOWANCE	1/8"
FLANGE RATING/FACING (ASA STD)	150 # RF
FITTINGS RATING	
JOINT EFF: SHELL	
STRESS RELIEVE?/RADIOGRAPH?	
WIND LOADING	
EARTHQUAKE BRACING	SEISMIC CLASS 2
STD. APPURTENANCE DWGS.	

APPLICABLE CODES & SPECS. API 620

WELDING SPECIFICATION

REV.	DESCRIPTION	ENG	DR	SUPV	
2	ISSUED FOR ENG'R CHANGE ORDER NO.1		IES		

Table 24-8

BECHTEL CORPORATION POWER DIVISION ENGINEERING	TANK DATA SHEET SHOP FABRICATED TANK CONCENTRATED ACID STORAGE TANK	JOB No 6750 6750-M-219	REV. 2
	CALVERT CLIFFS NUCLEAR POWER PLANT BALTIMORE GAS AND ELECTRIC COMPANY	SHEET 7 OF 13	

PLANT DATA BOOK 3/1975

18

ATTACHMENT 11, MCR COVERSHEET (Page 1 of 2)

MCR NO. 95 - 022 - 001 - 00
AIT NO. PE9500097 POSSIBLE MODE RESTRICTION ______

Page 1 of 2
CANCEL ____ Yes

I. INITIATION:

ES199502500

NED Due Date July 17, 1995
PES Due Date July 31, 1995
Schedule to work (QSS) Week G (226)

System Class: SR ______ NSR ✓
Priority 3 ~~5~~
MWO No. 0199403045
Unit Common

Proposed Change:
Provide valve for use at the Concentrated Sulfuric Acid Storage Tank Fill Connection. Refer to drawing and vendor information for possible changes.

Justification (list reference source or document)
OM & FSK drawings show different mark # valves. The FSK + OM configurations do not reflect the field configuration. The currently installed diaphragm valve is inadequate for th application. Three (3) maintenance orders have been generated in the past year to overhaul/repla

Originator: J. M. Mate Joseph M. Mate (PRINTED NAME AND SIGNATURE) Work Group: SSE4 Date: 01/26/95

Approved ______ Disapproved ______ Supervisor ______ (SIGNATURE) Date: ______

Comments: ______

II. PES REVIEW:

N/A ______

Yes ✓ No ____ Estimated total cost is less than $25,000?
Yes ✓ No ____ Estimated Engineering man-hours is less than 200?

Approved ✓ Disapproved ______ SE/RE J. M. Mate Joseph M. Mate (PRINTED NAME AND SIGNATURE) Date: 01/26/95

Approved ✓ Disapproved ______ PE [signature] (SIGNATURE) Date: 2/6/95

Comments: ______

III. ACCEPTABILITY:

Approved ______ Disapproved ______ PE-PDS/GS-DES ______ (SIGNATURE) Date ______

Comments: ______

IV. CAPITAL RECOVERY:

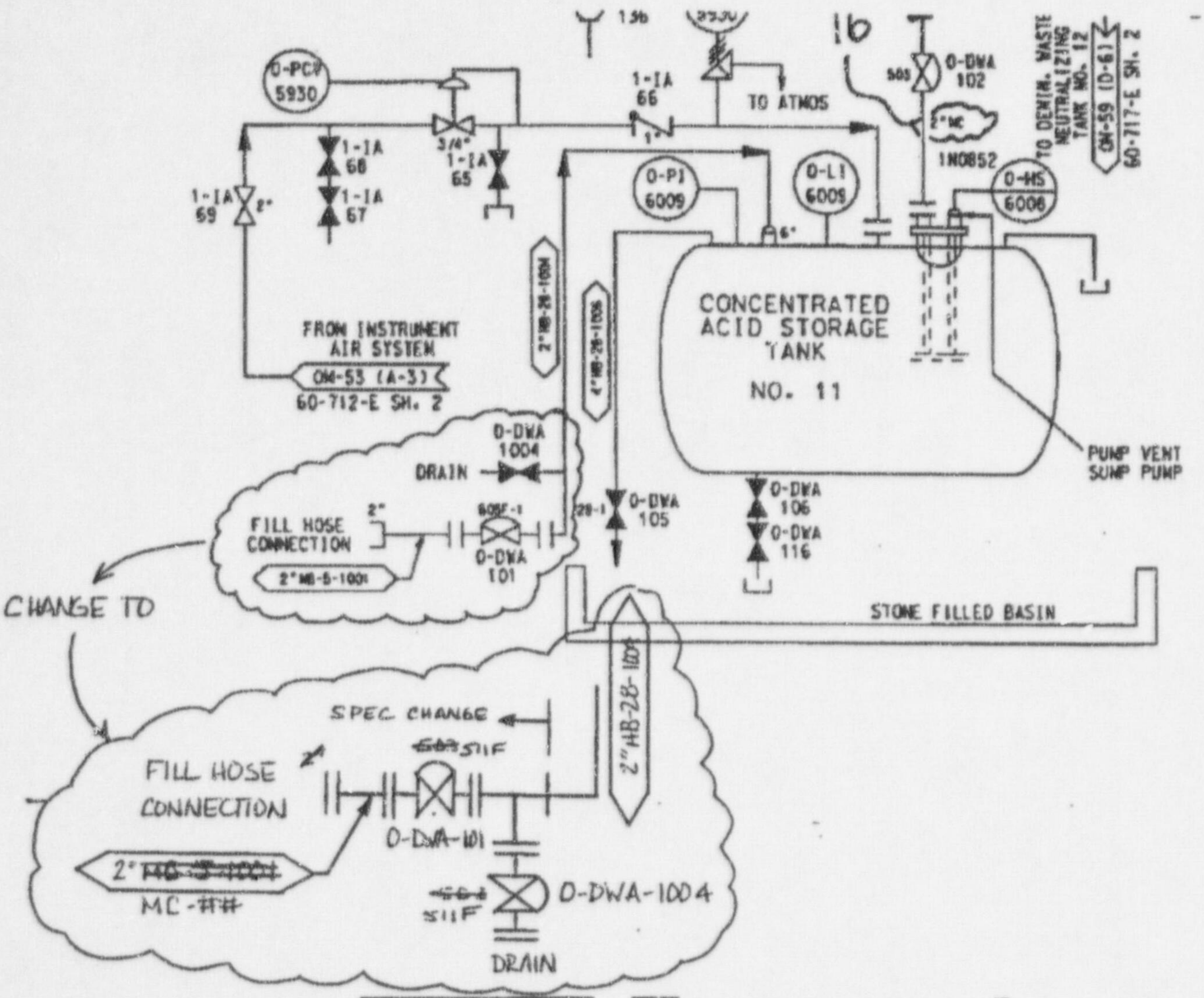
N/A ______

Management Systems Budget Unit Contact Date: ______

Contacted BY: ______ (PRINTED NAME AND SIGNATURE)

MCR Cost Accounting Charge No.: ______

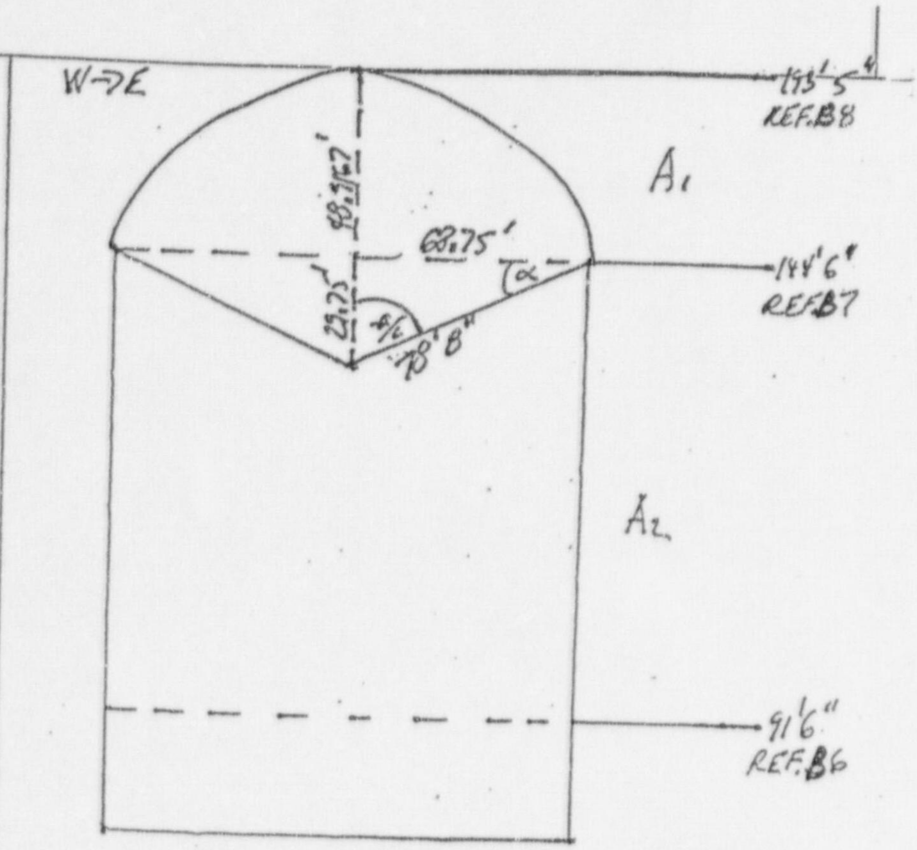
Comments: ______



MAKE-UP DEMINERALIZED WATER SYSTEM

BALTIMORE GAS AND ELECTRIC COMPANY NUCLEAR ENGINEERING DEPARTMENT			
CALVERT CLIFFS UNIT 1&2 ELECTRIC PRODUCTION PLANT			CAT. C
SCALE: NONE	VENDOR DWG. NO. OM-062SH0002		REV.
INTER NO. 16737.DGN	DWG. NO. 60720SH0002		16

ATTACHMENT G
CROSS SECTIONAL AREAS



$R = 78.6667'$ REF.B7

$C = 137.5'$ REF.B7

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

$\theta = 133.2011° = 2.3248$ r

$h = 48.9167'$

$d = 29.75'$

$S = R\theta = 182.8841$

$A_1 = \frac{1}{2}(Rs - cd) = 5148.13$ ft²

$A_2 = (137.5)(144.5 - 91.5) = 7287.5$ ft²

$A_{CTMT} = 12435.63$ ft²

$A_{AB} = (120'10" - 91'6") \cdot (66.1') = 1938.93$ ft²
(REF.B5, REF.B6, REF.B4)

$A_{TOT} = 2 * A_{CTMT} + A_{AB} = 26810.19$ ft²

TURBINE BUILDING: E→W

$A_{TB} = (138.5833 - 91.5) * (577') = 27167.06$ ft²
(REF.B8, REF.B6, REF.B4)

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

$A_{TB} = (138.5833 - 91.5) \cdot (182.25') = 8580.93$ ft²
(REF.B8, REF.B6, REF.B9)

$A_{CTMT} = 12435.63$ ft²

$A_{TOTAL} = 21016.56$ ft²