ATTACHMENT 19, CALCULATION COVER SHEET

INITIATION (Control Doc Type - DCALC)

Page 1 of 57

DCALC No.: CA04561 Revision No.: 0

Vendor Calculation (Check one): ☐ Yes ☒ No

ESP ES19801040 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: NITROGEN GAS 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: 8/11/98

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

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

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3. REVIEWER COMMENTS

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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).

CCNPP stores liquid nitrogen in the 11300 gal stainless steel storage tank located in the tank farm. The chemical habitability of the control room after a chemical release involving liquid nitrogen 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 liquid nitrogen can be stored in the 11300 gal stainless steel storage tank located in 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 liquid nitrogen are as follows:

		Peak Concentration (% v/v)
		Tank Farm
Current Configuration	No Recirculation	0.48
Modified Configuration	With Recirculation	0.12
Toxicity Limit (Asphyx)		15.00

Note that under the current and modified configurations, the peak control room concentrations under worst case conditions are less than the asphyxiation toxicity limit, defined as the amount of asphyxiant required to reduce the oxygen level to that at one mile of altitude (the altitude of Denver, Colorado). Nitrogen will not pose a flammability or explosion hazard in the control room, since nitrogen gas is nonflammable per Refs.5 and 9.

The current calculation incorporates many assumptions which make these results conservative. (1) An asphyxiation toxicity limit was utilized, defined as the amount of asphyxiant required to reduce the oxygen level to that at one mile of altitude (the altitude of Denver, Colorado). 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. (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: instant flashing of the entire quantity of Nitrogen.

6. INPUT DATA

The following input data is incorporated into this work:

(01) Chemical data for Nitrogen:

CAS number	7727-37-9	Refs.5,9
Chemical formula	N_2	Refs.5,9
Toxicity Limit (% v/v)	15.	Assumed
Odor threshold (ppm)	None	Refs.5,9
Volume fraction	1.00	Assumed
Volume (gal)	11300	Ref.10
Specific gravity (gm/cc)	0.807@-195.5°C	Refs.5,9
Boiling point (Degrees C) TB	-195.6	Ref.5
Molecular weight (gm/mole) MB	28.0	Refs.5,9
Lower flammable limit (Vol%)	Non-flammable	Refs.5,9

(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): 36.89

$r = SQRT(A/\pi) = SQRT[(11300gal)*(3785.422cc/gal)/(1.cm)/\pi*(1.E\text{-}4m^2/cm^2)] = 36.89m$

(l) Direction to source (deg):	339	Refs.B12,B14
(m) Source window (deg):	90	Refs.B13-B14
(n) Distance from source to receptor (m):	141.1	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:	CHTF3CR.OUT	
(r) JFT file name:	CHTF3CR.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): 17.16

σ_y=r/2.15=36.89/2.15=17.16 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	2.65E-04 sec/m^3
2- 8 hrs	2.14E-04 sec/m^3
8- 24 hrs	9.89E-05 sec/m^3
24- 96 hrs	6.92E-05 sec/m^3
96-720 hrs	5.66E-05 sec/m^3

(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):	36.89	

$r = SQRT(A/\pi) = SQRT[(11300gal)*(3785.422cc/gal)/(1.cm)/\pi*(1.E\text{-}4m^2/cm^2)] = 36.89m$

(l) Direction to source (deg):	358	Refs.B12,B14
(m) Source window (deg):	90	Refs.B13-B14
(n) Distance from source to receptor (m):	182.2	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:	CHTF3WR.OUT	TB
(r) JFT file name:	CHTF3WR.JFD	TB
(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): σ_y=r/2.15=36.89/2.15=17.16 m (Ref.B1)	17.16	
(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	1.75E-04 sec/m^3
2- 8 hrs	1.41E-04 sec/m^3
8- 24 hrs	6.57E-05 sec/m^3
24- 96 hrs	5.04E-05 sec/m^3
96-720 hrs	3.90E-05 sec/m^3

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

7. TECHNICAL ASSUMPTIONS

The following technical assumptions were utilized in this work:

(01) Per Refs.10 and 19, CCNPP stores liquid nitrogen in the 11300 gal stainless steel storage tank located in the tank farm.

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

(03) Based on the characteristics of nitrogen, all of the spilled material is assumed to immediately evaporate due to its low boiling point.

(04) An asphyxiation toxicity limit was utilized, defined as the amount of asphyxiant required to reduce the oxygen level to that at one mile of altitude (the altitude of Denver, Colorado). Per Ref.12 (Att.H), the air density at 0 km is 1.220 kg/m^3, while the air density at 10 km is 0.425 kg/m^3. Assuming a linear function between the logarithm of density and the altitude, the following algorithm can be generated:

$$\mathrm{Log}_{10}(\rho) = -0.045797 * z(\mathrm{km}) + 0.086360$$

Thus for z=1 mile=5280 ft=1.609 km, ρ = 1.029 kg/m^3.or 84.39% normal.

Thus at an altitude of 1 mile, the oxygen level is reduced by 15%. This is equivalent to replacing 15% of the air volume by nitrogen.

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) "Nitrogen System", System Description No. 74, Rev.0, 1/6/98.

(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) "Onsite Accidental Release of N_2 and H_2", Bechtel Calculation M-80-37, 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 the following methodology to calculate mass transfer from the spill site to the control room.

(01) This methodology is for liquids with boiling points less than the ambient temperature. For this case the entire inventory of toxic material is assumed to flash to a gaseous state in t seconds. The vapor density outside the control room is thus governed by the following equations.

VD = (M0/t)*ADC (gm/m^3)
PPM = (24500/MB)*VD

where
M0 = Inital mass of liquid (gm).
t = Flash time (sec)
ADC = Atmospheric dispersion coefficient (sec/m3)
MB = Toxic gas molecular weight (gm/mole)

The maximum concentration inside the control room can be readily calculated via the following:

VDC = VD*(1.-exp(-FCR/VCR*t/60)) (gm/m^3)

where
FCR = Control room inflow (cfm)
VCR = Control room volume (ft^3)
t = Flash time (sec)

Using a first order expansion of the equation for VDC as t goes to zero, the maximum concentration inside the control room can be readily obtained:

VDC = M0*ADC*FCR/VCR/60 (gm/m^3)

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)

(02) 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 concentrations inside the control room for a chemical spill in the tank farm is calculated via EXCEL spreadsheets captured in the following attachments using the methodology of Section 9:

Attachment D: 100% Liquid Nitrogen
for Current Control Room Configuration

Attachment E: 100% Liquid Nitrogen
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 stores liquid nitrogen in the 11300 gal stainless steel storage tank located in the tank farm. The chemical habitability of the control room after a chemical release involving liquid nitrogen 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 liquid nitrogen can be stored in the 11300 gal stainless steel storage tank located in 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 liquid nitrogen are as follows:

		Peak Concentration (% v/v)
		Tank Farm
Current Configuration	No Recirculation	0.48
Modified Configuration	With Recirculation	0.12
Toxicity Limit (Asphyx)		15.00

13. CONCLUSIONS

Under the current and modified configurations, the peak control room concentrations under worst case conditions are less than the asphyxiation toxicity limit, defined as the amount of asphyxiant required to reduce the oxygen level to that at one mile of altitude (the altitude of Denver, Colorado). Nitrogen will not pose a flammability or explosion hazard in the control room, since nitrogen gas is nonflammable per Refs.5 and 9.

The current calculation incorporates many assumptions which make these results conservative.
(1) An asphyxiation toxicity limit was utilized, defined as the amount of asphyxiant required to reduce the oxygen level to that at one mile of altitude (the altitude of Denver, Colorado). 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.
(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: instant flashing of the entire quantity of Nitrogen.

14. ATTACHMENTS

ATTACHMENT A
DATA FOR NITROGEN

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NGP500 **CAS:7727-37-9** **HR: 1**
NITROGEN
DOT: UN 1066/UN 1977
mf: N_2 mw: 28.02

PROP: Colorless, odorless, very stable, nonflammable gas; generally unreactive; colorless liquid or cubic crystals at low temp. Mp: −210.0°, d: 1.2506 g/L @ 0°, d (liquid): 0.808 g/cm³ @ −195.8°. Condenses to a liquid. Sltly sol in water; sol in liquid ammonia, alc.

SYNS: NITROGEN, compressed (UN 1066) (DOT) □ NITROGEN, refrigerated liquid (cryogenic liquid) (UN 1977) (DOT) □ NITROGEN GAS

CONSENSUS REPORTS: Reported in EPA TSCA Inventory.

DOT CLASSIFICATION: 2.2; *Label:* Nonflammable Gas

SAFETY PROFILE: Low toxicity. In high concentrations it is a simple asphyxiant. The release of nitrogen from solution in the blood, with formation of small bubbles, is the cause of most of the symptoms and changes found in compressed air illness (caisson disease). It is a narcotic at high concentration and high pressure. Both the narcotic effects and the bends are hazards of compressed air atmospheres such as found in underwater diving. Nonflammable gas. Can react violently with lithium, neodymium, titanium under the proper conditions. See also ARGON.

NGQ500 **CAS:10025-85-1** **HR: 3**
NITROGEN CHLORIDE
mf: Cl_3N mw: 120.37

PROP: Very unstable, volatile, yellowish oil or rhombic crystals; pungent odor. Mp: <−40°, explodes above 60°, bp: <71°, d: 1.653, vap press: 150 mm @ 20°. Sol in CCl_4, $CHCl_3$.

SYNS: AGENE □ CHLORINE NITRIDE □ NITROGEN TRICHLORIDE □ NITROGEN TRICHLORIDE (DOT) □ TRICHLORAMINE □ TRICHLORINE NITRIDE

TOXICITY DATA WITH REFERENCE
ihl-rat LC50:112 ppm/1H AIHAAP 44,145,83

DOT CLASSIFICATION: Forbidden

SAFETY PROFILE: Moderately toxic by inhalation. An irritant to the eyes, skin, mucous membranes, and a systemic central nervous system irritant. An explosive sensitive to impact, light, and ultrasound. The solid explodes on melting. The liquid explodes above 60°C. Concentrated solutions are also explosive. Explosive decomposition is initiated by contact with: concentrated ammonia, arsenic, dinitrogen tetraoxide, hydrogen sulfide, hydrogen trisulfide, nitrogen oxide, organic matter, ozone, phosphine, phosphorus, potassium cyanide, potassium hydroxide solutions, selenium, hydrogen chloride, hydrogen fluoride, hydrogen bromide, hydrogen iodide. Mixtures with chlorine + hydrogen are potentially explosive. Upon decomposition it emits toxic fumes of Cl^- and NO_x. See also CHLORIDES.

NGR000 **HR: 3**
NITROGEN CHLORIDE DIFLUORIDE
mf: ClF_2N mw: 87.46

SAFETY PROFILE: Very unstable. Use caution in handling.

NGR500 **CAS:10102-44-0** **HR: 3**
NITROGEN DIOXIDE
mf: NO_2 mw: 46.01

PROP: Brown gas or colorless solid to yellow liquid; irritating odor. Reacts with H_2O giving HNO_3 + NO. Mp: −9.3° (yellow liquid), bp: 21° (red-brown gas with decomp), d: 1.491 @ 0°, vap press: 400 mm @ 80°. Liquid below 21.15°. Sol in concentrated sulfuric acid, nitric acid. Corrosive to steel when wet.

SYNS: AZOTE (FRENCH) □ AZOTO (ITALIAN) □ NITRITO □ NITROGEN PEROXIDE □ RCRA WASTE NUMBER P078 □ STICKSTOFFDIOXID (GERMAN) □ STIKSTOFDIOXYDE (DUTCH)

TOXICITY DATA WITH REFERENCE
mmo-sat 6 ppm MUREAV 136,119,84
sce-ham:lng 5 ppm/10M-C MUREAV 89,303,81
ihl-mus TDLo:22 ppm (female 7-18D post):REP NRTXDN 9,545,88
ihl-rat TCLo:85 µg/m³/24H (female 1-22D post):TER GISAAA 42(12),22,77
ihl-hmn LCLo:200 ppm/1M AOHYA3 17,159,74
ihl-man TCLo:6200 ppb/10M:PUL KEKHA7 17,337,68
ihl-man TCLo:90 ppm/40M:PUL JOCMA7 8,301,66
ihl-rat LC50:88 ppm/4H AMIHBC 10,418,54
ihl-mus LC50:1000 ppm/10M JCTODH 4,246,77
ihl-dog LCLo:123 mg/m³ TXAPA9 9,160,66
ihl-mky LCLo:123 mg/m³/8H TXAPA9 9,160,66
ihl-rbt LC50:315 ppm/15M AIHAAP 23,457,62
ihl-gpg LC50:30 ppm/1H AEHLAU 10,220,65

CONSENSUS REPORTS: Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program.

OSHA PEL: STEL 1 ppm
ACGIH TLV: TWA 3 ppm; STEL 5 ppm
DFG MAK: 5 ppm (9 mg/m³)
NIOSH REL: CL (Oxides of Nitrogen) 1 ppm/15M

SAFETY PROFILE: Experimental poison by inhalation. Moderately toxic to humans by inhalation. An experimental teratogen. Other experimental reproductive effects. Human systemic effects by inhalation: pulmonary vascular resistance changes, cough, dyspnea, and other pulmonary changes. Mutation data reported. Violent reaction with cyclohexane; F_2; formaldehyde and alcohols; nitrobenzene; petroleum; toluene. When heated to decomposition it emits toxic fumes of NO_x. See also NITRIC OXIDE.

For occupational chemical analysis use OSHA: #ID-109 or NIOSH: Nitrogen Dioxide, 6700.

NGS500 **CAS:13847-65-9** **HR: 3**
NITROGEN FLUORIDE OXIDE
mf: F_3NO mw: 87.01

PROP: Colorless gas. Strong oxidizing agent. Stable in glass. Resistant to hydrolysis. Mp: −160°, bp: −87°.

N

NITROGEN

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NXX

Common Synonyms	Gas	Colorless	Odorless
Liquid nitrogen	Floats and boils on water.		

Avoid contact with liquid.

Fire	Not flammable.
Exposure	CALL FOR MEDICAL AID. **VAPOR** Not harmful. In high concentrations may cause dizziness, difficult breathing, or loss of consciousness. **LIQUID** Will cause frostbite. Flush affected areas with plenty of water. DO NOT RUB AFFECTED AREAS.
Water Pollution	Not harmful to aquatic life.

1. RESPONSE TO DISCHARGE
(See Response Methods Handbook)
Restrict access

2. LABEL
2.1 Category: Nonflammable gas
2.2 Class: 2

3. CHEMICAL DESIGNATIONS
3.1 CG Compatibility Class: Not listed
3.2 Formula: N_2
3.3 IMO/UN Designation: 2/1977
3.4 DOT ID No.: 1977
3.5 CAS Registry No.: 7727-37-9

4. OBSERVABLE CHARACTERISTICS
4.1 Physical State (as shipped): Liquefied gas
4.2 Color: Colorless to faint yellow
4.3 Odor: None

5. HEALTH HAZARDS
5.1 Personal Protective Equipment: Safety glasses or face shield; insulated gloves; long sleeves; trousers worn outside boots or over high-top shoes to shed spilled liquid; self-contained breathing apparatus where insufficient air is present.
5.2 Symptoms Following Exposure: Inhalation can cause asphyxiation, if atmosphere does not contain oxygen; dizziness, unconsciousness, or even death can result. Contact of liquid with skin or eyes causes frostbite burns.
5.3 Treatment of Exposure: INHALATION: remove to fresh air; apply artificial respiration if breathing has stopped; call physician. EYES: treat for frostbite burns caused by liquid. SKIN: treat for frostbite; soak in lukewarm water.
5.4 Threshold Limit Value: Non-toxic
5.5 Short Term Inhalation Limits: Not pertinent
5.6 Toxicity by Ingestion: Not pertinent
5.7 Late Toxicity: None
5.8 Vapor (Gas) Irritant Characteristics: None
5.9 Liquid or Solid Irritant Characteristics: Frostbite
5.10 Odor Threshold: Not pertinent
5.11 IDLH Value: Data not available

6. FIRE HAZARDS
6.1 Flash Point: Not pertinent (nonflammable compressed gas)
6.2 Flammable Limits in Air: Not pertinent
6.3 Fire Extinguishing Agents: Not pertinent
6.4 Fire Extinguishing Agents Not to be Used: Not pertinent
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Containers may explode when heated.
6.7 Ignition Temperature: Not pertinent
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: Not pertinent
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: Heat of water will vigorously vaporize liquid nitrogen.
7.2 Reactivity with Common Materials: No chemical reaction. Low temperature may cause brittleness in rubber and plastics.
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: Data not available

8. WATER POLLUTION
8.1 Aquatic Toxicity: None
8.2 Waterfowl Toxicity: None
8.3 Biological Oxygen Demand (BOD): None
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION
9.1 Grades of Purity: 99.5+%
9.2 Storage Temperature: −320°F
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open

10. HAZARD ASSESSMENT CODE
(See Hazard Assessment Handbook)
A-C-D-F-G

11. HAZARD CLASSIFICATIONS
11.1 Code of Federal Regulations: Nonflammable gas
11.2 NAS Hazard Rating for Bulk Water Transportation: Not listed
11.3 NFPA Hazard Classification:

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

12. PHYSICAL AND CHEMICAL PROPERTIES
12.1 Physical State at 15°C and 1 atm: Gas
12.2 Molecular Weight: 28.0
12.3 Boiling Point at 1 atm: −320.1°F = −195.8°C = 77.4°K
12.4 Freezing Point: −354°F = −215°C = 58°K
12.5 Critical Temperature: −232.6°F = −147.0°C = 126.2°K
12.6 Critical Pressure: 493 psia = 33.5 atm = 3.40 MN/m²
12.7 Specific Gravity: 0.807 at −195.5°C (liquid)
12.8 Liquid Surface Tension: 8.3 dynes/cm = 0.083 N/m at −193°C
12.9 Liquid Water Interfacial Tension: Not pertinent
12.10 Vapor (Gas) Specific Gravity: 0.965
12.11 Ratio of Specific Heats of Vapor (Gas): 1.3962
12.12 Latent Heat of Vaporization: 85 Btu/lb = 53 cal/g = 2.2 X 10^5 J/kg
12.13 Heat of Combustion: Not pertinent
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: 6.15 cal/g
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: Data not available

NOTES

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
                                 e-mail: jyl1@nrc.gov
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                                 e-mail: jjh@nrc.gov
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                                 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

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   8/26/1998  at  08:36:30

 ******* 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)              =    36.89

    Direction .. intake to source (deg)   =      339
    Wind direction sector width  (deg)    =       90
    Wind direction window  (deg)          =   294 - 024
    Distance to intake  (m)               =    141.1
    Intake height   (m)                   =     15.6
    Terrain elevation difference  (m)     =       .0

    Output file names
      CHTF3CR.out
      CHTF3CR.jfd

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

    Initial value of sigma y              =    17.16
    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               =   7383
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  18013

    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	7878.	9361.	11227.	13690.	15731.	19609.	24938.	25103.	25169.	24910.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	18013.	16464.	14480.	11796.	9937.	5975.	267.	1.	0.	0.
TOTAL X/Qs	25891.	25825.	25707.	25486.	25668.	25584.	25205.	25104.	25169.	24910.
% NON ZERO	30.43	36.25	43.67	53.72	61.29	76.65	98.94	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

2.65E-04	2.58E-04	2.47E-04	2.27E-04	1.87E-04	1.42E-04	8.72E-05	7.72E-05	6.73E-05	6.07E-05

95% X/Q for standard averaging intervals

0 to 2 hours	2.65E-04
2 to 8 hours	2.14E-04
8 to 24 hours	9.89E-05
1 to 4 days	6.92E-05
4 to 30 days	5.66E-05

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HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	3.50E-04	3.10E-05
SECTOR-AVERAGE	2.20E-04	1.94E-05

NORMAL PROGRAM COMPLETION

ATTACHMENT C
ARCON96 RUNS 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

Date:           [illegible] 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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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   8/26/1998  at  08:37:00

 ******* 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)                       =   155.0
    Effluent vertical velocity  (m/s)          =      .00
    Vent or stack flow  (m^3/s)                =      .00
    Vent or stack radius  (m)                  =    [illegible].89

    Direction .. intake to source (deg)  =     358
    Wind direction sector width  (deg)   =      90
    Wind direction window  (deg)         =   313 - 043
    Distance to intake  (m)              =   182.2
    Intake height  (m)                   =     9.1
    Terrain elevation difference  (m)    =      .0

    Output file names
      CHTF3WR.out
      CHTF3WR.jfd

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

    Initial value of sigma y             =    17.16
    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               =   7453
    Hours elevated plume w/ dir. in window  =      0
    Hours of calm winds                     =    495
    Hours direction not in window or calm   =  17943
```

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	7948.	9433.	11303.	13804.	15889.	19671.	25021.	25101.	25169.	24910.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	17943.	16392.	14404.	11682.	9779.	5913.	184.	3.	0.	0.
TOTAL X/Qs	25891.	25825.	25707.	25486.	25668.	25584.	25205.	25104.	25169.	24910.
% NON ZERO	30.70	36.53	43.97	54.16	61.90	76.89	99.27	99.99	100.00	100.00

95th PERCENTILE X/Q VALUES

1.75E-04	1.71E-04	1.63E-04	1.50E-04	1.25E-04	9.37E-05	6.13E-05	5.29E-05	4.64E-05	4.19E-05

95% X/Q for standard averaging intervals

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0 to 2 hours	1.75E-04
2 to 8 hours	1.41E-04
8 to 24 hours	6.57E-05
1 to 4 days	5.04E-05
4 to 30 days	3.90E-05

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	2.36E-04	2.12E-05
SECTOR-AVERAGE	1.48E-04	1.33E-05

NORMAL PROGRAM COMPLETION

ATTACHMENT D
EXCEL SPREADSHEET
NITROGEN - AUX BLDG ROOF INLET

NITROGEN						
CHEMICAL		N2				
TLV (PPM)	TLV					
ODOR THRESHOLD (PPM)	OT					
STORAGE QTY (GAL)	Q	11300				
STORAGE PURITY (FRACTION)	QF	1				
SPECIFIC GRAVITY (GM/CC)	SG	0.807				
MOLECULAR WT (GM/MOLE)	MB	28				
VOL-CR (CF)	VCR	234157				
Q-CR (CFM)	FCR	8300				
MASS DENSITY AIR (GM/CC)	RHOA	1.21E-03				
INITIAL MASS (GM)	M0	Q*QF*SG*(3785.422 CC/GAL)				3.4520E+07
VOLUME (M3)	VO	Q*QF*(3.785422E-3 M3/GAL) =				4.2775E+01
SPILL RADIUS INITIAL (M)	RO	(V0/PI)^0.33333 =				2.3879E+00
SPILL AREA INITIAL (M2)	AO	PI*RO^2 =				1.7913E+01
SPILL AREA FINAL (M2)	AF	VO/0.01 =				4.2775E+03
DELTA SPILL AREA (M2/SEC)	DA	SQRT(4*PI*9.81*VO*(SG-RHOA)/SG))				7.2562E+01
TIME TO MAX AREA (SEC)	tA	(AF-AO)/DA =				5.8703E+01
		TF				
ADC (S/M3)	ADC	2.65E-04				
VAPOR DEN INSIDE CR(GM/M3)	VDC=	M0*ADC*FCR/VCR/60.				
	PPM=	(24500/MB)*VD				
CASES	ADC	VDC	PPM	%-v/v		
	2.65E-04	5.40E+00	4.73E+03	0.4729		

ATTACHMENT E
EXCEL SPREADSHEET
NITROGEN - WEST ROAD INLET

NITROGEN							
CHEMICAL		N2					
TLV (PPM)	TLV						
ODOR THRESHOLD (PPM)	OT						
STORAGE QTY (GAL)	Q	11300					
STORAGE PURITY (FRACTION)	QF	1					
SPECIFIC GRAVITY (GM/CC)	SG	0.807					
MOLECULAR WT (GM/MOLE)	MB	28					
VOL-CR (CF)	VCR	234157					
Q-CR (CFM)	FCR	3000					
MASS DENSITY AIR (GM/CC)	RHOA	1.21E-03					
INITIAL MASS (GM)	M0	Q*QF*SG*(3785.422 CC/GAL)					3.4520E+07
VOLUME (M3)	VO	Q*QF*(3.785422E-3 M3/GAL) =					4.2775E+01
SPILL RADIUS INITIAL (M)	RO	(V0/PI)^0.33333 =					2.3879E+00
SPILL AREA INITIAL (M2)	AO	PI*RO^2 =					1.7913E+01
SPILL AREA FINAL (M2)	AF	VO/0.01 =					4.2775E+03
DELTA SPILL AREA (M2/SEC)	DA	SQRT(4*PI*9.81*VO*(SG-RHOA)/SG))					7.2562E+01
TIME TO MAX AREA (SEC)	tA	(AF-AO)/DA =					5.8703E+01
		TF					
ADC (S/M3)	ADC	1.75E-04					
VAPOR DEN INSIDE CR(GM/M3)	VDC=	M0*ADC*FCR/VCR/60.					
	PPM=	(24500/MB)*VD					
CASES	ADC	VDC	PPM	%-v/v			
	1.75E-04	1.29E+00	1.13E+03	0.1129			

ATTACHMENT F
SYSTEM DESCRIPTION # 74

THIS DOCUMENT IS FOR INSTRUCTION AND INFORMATION ONLY. IT IS NOT TO BE USED FOR PLANT OPERATIONS.

NITROGEN SYSTEM
SYSTEM DESCRIPTION
NO. 74
REVISION 0

Baltimore Electric and Gas Company
Calvert Cliffs Nuclear Power Plant

Prepared By: ____________ Date: 12/2_ /97
System Engineer

Reviewed By: ____________ Date: 12/22/97
System Manager/Work Group Leader

Approved By: ____________ Date: 1-6-98
Principal Engineer

PLEASE DIRECT TO THE SUPERVISOR-OPERATIONS TRAINING OR THE SYSTEM ENGINEER, ANY RECOMMENDATIONS FOR IMPROVEMENTS TO THIS SYSTEM DESCRIPTION.

TABLE OF CONTENTS

LIST OF TABLES

CALVERT CLIFFS NUCLEAR POWER PLANT
SYSTEM DESCRIPTION #74
NITROGEN SYSTEM

1.0 SYSTEM PURPOSE

The purpose of the Nitrogen Gas System is to store and distribute nitrogen (N_2) gas to various plant components throughout tne turbine building, auxiliary building and the tank farm.

2.0 GENERAL DESCRIPTION

The Nitrogen (N_2) system can be divided into two general subsystems, the storage system and the distribution header. The storage system consists of an insulated storage tank which is kept pressurized by an ambient vaporizer. An electric vaporizer is installed for use in the event the ambient vaporizer is out of service. The storage tank is kept under pressure to maintain the nitrogen in a liquid state.

The distribution header runs throughout the plant, going to a variety of components, ranging from the main steam isolation valves to the auxillary boilers, N_2 is used in virtually all storage tanks and water bearing vessels such as the volume control tank and the steam generators.

Nitrogen, like all cryogenic fluids, has a very low boiling point (-320° F) and in its liquid form can cause severe frostbite if it comes in contact with exposed parts of the human body. Additionally, while it makes up around 70% of the air we breath, **NITROGEN CAN NOT SUSTAIN LIFE** on its own (without OXYGEN). Therefore, care must be taken whenever working in an area (or component) where N_2 is present to ensure the air is constantly monitored for habitability.

3.0 DETAILED DESCRIPTION

*** All setpoints given in this description are approximate**

3.1 LIQUID NITROGEN STORAGE UNIT

3.1.1 STORAGE TANK

The storage tank is an 11,300 gallon stainless steel tank surrounded by perlite powder insulation and a protective outer carbon steel tank. The space between the inner and outer tank is at a vacuum of approximately 28" HG (similar to a "THERMOS" bottle), since heat transfer through a vacuum is much lower than through air. Liquid nitrogen is brought on site by a vendor's truck, and put directly into the storage tank via the fill connection . The fill line is protected from over pressure conditions by a relief valve, 0-RV-6354, set for ~450 PSI. Over pressure protection for the tank is provided by relief valves and rupture disks. The tank relief valves, located in the outlet piping of the pressure build-up coil are arranged so that either RV-6358 or RV-6359 can be selected on service by a three way valve. These relief valves are set at ~285 PSIG. The two rupture disks are mounted in the same piping run, and are designed to burst at ~315 PSIG. Local indication of pressure and level in the storage tank is provided. The level indicator, LI-6300, indicates in inches of water pressure (one inch of water equals ~55 gallons of liquid nitrogen.). LI-6300 covers a range of 0 to 400 inches, where any reading between 90 and 210 inches is normal. Tank pressure is indicated by PI-6367, with a range of 0 to 800 PSIG (normal tank pressure is about 240 PSIG).

Nitrogen pressure in the storage tank is maintained by a pressure build-up coil. Liquid nitrogen exits the storage tank through manual throttle valve 0-N_2-407 to pressure control valves PCV-6343 or 6344. The nitrogen the enters the pressure build-up coils, where the nitrogen absorbs heat from the atmosphere, vaporizing and pressurizing the nitrogen in the coil. This gaseous nitrogen is then directed back to the top of the storage tank, through a pressure control valve (PCV-6342) thereby keeping the tank contents under pressure, and thus in a liquid state. PCV-6342 is provided with a small manual bypass valve.

3.1.2 NITROGEN VAPORIZATION

Nitrogen supply to the vaporizer is taken from the storage tank via a dip-tube at the bottom of the tank, ensuring only liquid is drawn out. This liquid nitrogen is routed to either the ambient or the electric vaporizer which keep the nitrogen header pressure at around 240 PSIG.

3.1.2.1 AMBIENT VAPORIZER

The Ambient Vaporizer (constructed of aluminum) absorbs heat from the atmosphere and transmits it to the nitrogen. The ambient vaporizer is of the fin and tube design, with a center tube radiating 8 fins outward for the entire 12 foot length of the tube. The vaporizer has 2 sections of tubes mounted vertically, with each section consisting of 64 tubes. The ambient vaporizer is rated at 33,000 SCFM at 500 PSIG. If the ambient vaporizer is isolated or its temperature gets too low (-100°F AT TS-6301), the electric vaporizer (if in automatic) will be energized.

3.1.2.2 ELECTRIC VAPORIZER

The Electric Vaporizer is a three stage electric in-line-heater whose purpose is to maintain nitrogen pressure at approximately 240 PSIG. The three sections of heaters cycle on the nitrogen outlet temperature (~70°F ON/~90°F OFF) with a high temperature cut-off at ~300°F. Each stage consists of 6 individual heaters. There is a low temperature switch that shuts the outlet solenoid valve if the temperature drops to -20°F, so that liquid nitrogen is not released to the system. The electric vaporizer is powered from 480 VAC BUS 25. The vaporizer has a local control panel (located next to the N_2 storage tank) that contains a local breaker, hand switch, power availability light, heater on light, and system temperature controls.

3.2 ALTERNATE NITROGEN SUPPLY

The N_2 system is equipped with a truck supply connection located near the north intake stairwell 45' elevation, so that a truck can be lined up to the system to act as its supply, in the event the storage system is inoperable or depleted due to excessive use. A manual isolation valve (0- N_2-102) is situated just downstrean of the truck connection.

3.3 NITROGEN DISTRIBUTION HEADER

3.3.1 CONDENSATE STORAGE SPARGING AND BLANKETING SYSTEM

The nitrogen gas system supplies N_2 to the three condensate storage tanks and to the demineralized water storage tank. This N_2 is used for blanketing and/or sparging the water in the tanks. This is done to keep oxygen out of the tanks, thus reducing corrosion, both in the tanks themselves and in the systems they supply with water. All three condensate storage tanks and the demineralized water storage tank are blanketed with N_2, while only 12 condensate storage and the demineralized water storage tanks have sparging tubes, which bubble N_2 up from the bottom of the tank. The N_2 to the sparging and blanketing system is supplied via pressure control valves, PCV-6300 or 6301, which tap off the distribution header just after the header leaves the N_2 storage tank and before it goes through the pipe tunnel into the turbine building. The PCVs lower the N_2 pressure to 25 PSIG. Downstream of the PCVs there is a pressure switch and a flow alarm which alerts the control room to any loss of N_2 to the sparging and blanketing systems. The N_2 pressure is further reduced at each of the water storage tanks by regulators that bring the N_2 pressure to 1 1/2 " H_2O, which is about .054 PSIG. The tank vents and overflows are sealed with rupture disks, preventing the escape of N_2. These rupture disks burst at ~3 PSIG differential pressure. Condensate storage tanks 11 and 21, in addition to the demineralized water storage tank, have two overpressure-vacuum breaker relief valves for protection from damage caused by either a vacuum or an overpressure condition. 12 condensate storage tank has a six inch vacuum breaker and two glycol charged loop seals in conjunction with a vent valve for overpressure protection.

3.3.2 TURBINE BUILDING HEADER

The nitrogen header proceeds from the storage unit in the tank farm to the turbine building through the pipe tunnel at the north end of the turbine building. Nitrogen is supplied to the turbine building for placing the feed water heaters, auxilary boilers, main generators and the steam generator feed pumps in long term lay-up. N_2 is also used as an alternate way of charging the auxilary feed pump air accumulators and provisions have been made to have the N_2 System act as a back up to the instrument air system.

3.3.2.1 N_2 TO INSTRUMENT AIR BACK UP (NOT CURRENTLY IN SERVICE)

N_2 was planned as a backup to the Instrument Air System in the event of a loss of instrument air. This line taps off the N_2 header just after it enters the turbine building from the tank farm, through manual valve 0- N_2-445, located on the 12' turbine building, northeast corner. In the event of a loss of instrument air , control valves 1 (2) -PCV-6301 were to open allowing N_2 to pressurize the header. This system is installed but is not in service.

3.3.2.2 **AUXILIARY BOILERS**

N_2 for blanketing the Auxiliary Boilers is supplied through a pressure control valve (1-PCV-6298) at ~5 PSIG. This valve is located in the auxiliary boiler room. The N_2 then must pass through a spool piece and the normal vent into the boilers.

3.3.2.3 **NITROGEN GENERATING SYSTEM**

The N_2 Generating System is retired in place.

3.3.2.4 **AUXILIARY FEED WATER AIR ACCUMULATORS**

Nitrogen serves as a back up way of charging the accumulators in the event of loss of motive air to the amplifier. Charging the accumulators with N_2 is accomplished manually with valves 0-N_2-104 (0-N_2-106) and 0-N_2-105 (0-N_2-107) located in the service water pump rooms.

3.3.2.5. **HIGH AND LOW PRESSURE FEED WATER HEATERS**

N_2 to the Feed Water Heaters is supplied through a pressure control valve, 1-PCV-6299 (2-PCV-6299), at a pressure of ~5 PSIG. The nitrogen to the individual feed water heaters is supplied through removable flexible hoses to both the shell and tube sides of 13 thru 16 (23 thru 26) feed water heaters, while it is only supplied to the tube sides of feed water heaters 11 and 12 (21 and 22). Unit-1's control valve is located north of the Unit-1 service water pump room door. Unit-2's control valve is located outside of the Unit-2 auxiliary feed pump room door. The connection for the steam generator feed pumps taps off downstream of the feed water heaters on both units.

3.3.2.6 **STEAM GENERATOR FEED PUMPS**

The nitrogen for use in the Steam Generator Feed Pumps is supplied from the same header that supplies the feed water heaters, through a flexible hose at each pump.

3.3.2.7 **MAIN GENERATOR**

N_2 is used in the Main Generator for long term lay-up to keep air out and provide a clean and inert atmosphere. Since no permanent piping exists between the generator and the N_2 system , temporary hoses must be installed between the N_2 header and the generator gas system. On Unit 1 the temporary hose is connected at the N_2 low point drain (0-N_2-258) next to the turbine building operators booth and runs to the generator gas system. On Unit 2 the temporary hose connects to one of the feed water heater connections and runs to the generator gas system.

3.3.3 AUXILIARY BUILDING HEADER

Nitrogen is used in the auxiliary building for a variety of reasons. Compressed, it is used as the driving force behind the safety injection tanks, as well as the force that shuts the main steam isolation valves. N_2 Is used as a vacuum break for the waste gas surge tank, and as an inert sealing media for the electrical penetration canisters The N_2 header in the auxiliary building is divided (by unit) by valve 0-N_2-255, which is located in the 5 foot elevation of the auxiliary building, near the elevator.

3.3.3.1 ELECTRICAL PENETRATION CANISTERS

N_2, at ~50 PSIG, is supplied to the canisters, first through pressure control valves 1-PCV-6326, 6328 and 2-PCV-6326, 6328 and then a flexible hose with a small compression fitting at the end of it. Individual canisters are charged with N_2 through their low pressure alarm switches. The nitrogen is used in these canisters as an inert sealing medium between the containment and the penetration room. The hoses, pressure control valves and pressure switches are located in each 45' electrical penetration room in the auxiliary building

3.3.3.2 MAIN STEAM ISOLATION VALVE ACTUATOR N_2 COMPRESSOR

The Main Steam Isolation Valves are shut using nitrogen pressure. Since the N_2 header pressure is only around 240 PSIG, the N_2 compressor is used to compress the nitrogen to the pressure required (approximately 2800 PSI) to shut the valve. The N_2 does not shut the valve directly from the N_2 header, but is stored in an accumulator on the top of the valve, for use when necessary. The compressor is driven by plant air.

3.3.3.3 SAFETY INJECTION TANKS

The Safety Injection Tanks hold a borated water volume with a 200-250 PSI nitrogen cap on top, which is used to force the borated water into the RCS during accident conditions. The manual valve (0-N_2-236 on Unit-1 and 0-N_2-270 on Unit-2) on this line is located in the 27' east penetration room.

3.3.3.4 **REACTOR COOLANT DRAIN TANK**

Nitrogen is used in the Reactor Coolant Drain Tank to prevent hydrogen from coming out of solution and creating a potentially explosive condition. This N_2 is regulated by a pressure control valve (1(2)-PCV-6317), that maintains N_2 pressure to the drain tank at ~2 PSI. This pressure control valve is located in each unit's 27' east penetration room.

3.3.3.5 **STEAM GENERATORS**

Nitrogen is used in the Steam Generators for lay-up conditions, to prevent the entry of oxygen. The N_2 to the steam generators is regulated at~ 3 PSI by control valve 1(2)-PCV-6318 (which is also the control valve for the N_2 to the pressurizer quench tank). There are flexible hoses in the line down stream of the control valves which connect the N_2 system to the steam generator piping in the containment.

3.3.3.6 **PRESSURIZER QUENCH TANK**

Nitrogen is used in the Quench Tank as a purge gas, to prevent the build-up of hydrogen gas to an explosive level. 1(2)-PCV-6318 controls N_2 pressure to the quench tank at ~3 PSI. 1(2)-PCV-6318 is located in the respective units 27' east penetration room.

3.3.3.7 **VOLUME CONTROL TANK (VCT)**

Nitrogen is used in the VCT for degassification (removal of H_2 and radioactive gases). The N_2 line leading into the VCT has a flow orifice installed upstream of a manual inlet valve (0-N_2-250 on Unit-1 and 0-N_2-256 on Unit-2) which is located in the respective unit's BAST room.

3.3.3.8 **DEGASSIFIER**

Nitrogen is used in the Degassifier as a purge gas (removal of H_2 gas, etc) and is supplied through 1(2)-PCV-6315 at a pressure of ~ 30 PSIG. Unit-1's pressure control valve is located outside of 11 degassifier room on the 5'elevation of the auxiliary building, and Unit-2's is located in the 5' auxiliary building valve alley.

3.3.3.9 **WASTE GAS SURGE TANK**

N_2 is supplied to the Waste Gas Surge Tank as a purge gas, and also as a means of breaking vacuum in the tank. The N_2 going into the waste gas surge tank is first reduced to ~5 PSI by a pressure control valve (0-PCV-6316) before going to either the vacuum breaker or the manual valve used in purging the tank. There is a relief valve in this line that relieves at ~50 PSI. The vacuum breaker, 0-PCV-2182, is set to open at ~0 PSIG, protecting the surge tank from damage. The control valves are both located in the 5 foot auxiliary building in the hallway across from the hot tool shop.

3.3.3.10 **ION EXCHANGERS**

N_2 is used in the Ion Exchangers for fluffing the resin beds. The N_2 is supplied to the ion exchanger header through pressure control valve 0-PCV-6331 at a pressure of ~20 PSIG. This valve is located on the 27' of the auxiliary building outside the Unit-1 degassifier filter room. The manual isolations to the pressure control valve are 0-N_2-584 and 585, located in the Unit-1 27' penetration room and out side the Unit-1 degassifier filter room, respectively.

3.3.3.11 **COOLANT WASTE EVAPORATORS**

N_2 is used in the Evaporators to break vacuum during system shutdown and blanketing during long term lay-up. The N_2 is supplied to the evaporator concentrator through two control valves (0-CV-9462/9512 located in the evaporator room) which allow N_2 to break the vacuum in the concentrator but prevent the over-pressurization of the vessel by shutting at ~0 PSI. The evaporators are supplied by a common N_2 line that taps off the main auxiliary building header upstream of the unit cross-connect valve 0- N_2-255. The manual isolation for this line is 0-N_2-343, located outside of U-1's VCT room. This line also has a pressure control valve (0-PCV-6321) in it upstream of the evaporators, limiting N_2 pressure to the evaporators to ~100 PSI. This valve is located in the evaporator room.

3.3.3.12 **POST LOCI SAMPLING SYSTEM**

N_2 is used in the Post Loci Sampling System as a means of diluting radioactive gases in the sample line. The cutout valve for this is 0- N_2-387, located in the Unit-2 45' west penetration room. This line taps off the Unit-2 side of the auxiliary building header only.

3.3.3.13 **RAD CHEM STORAGE LOCKERS**

N_2. used as a purge gas and test standard .

TABLE 5-1

PERTINENT SYSTEM DESIGN CHARACTERISTICS

NITROGEN STORAGE TANK	
CAPACITY	11,300 GALLONS
OPERATING PRESSURE	250-280 PSIG
OPERATING TEMPERATURE	-250°F
MATERIALS	
INSULATION	PERLITE
INNER TANK	STAINLESS STEEL
OUTER TANK	
CARBON STEEL	
ELECTRIC VAPORIZER	
MODEL	2X2TLE50X100KW
POWER RATING	100KW
MATERIALALUMINUM CAST	
OPERATING PRESSURE	300 PSIG
TEST PRESSURE	375 PSIG
AMBIENT VAPORIZER	
MODEL	TF 6410 HF
DESIGN WORKING PRESSURE	500 PSIG
OPERATING PRESSURE	250-280 PSIG
CAPACITY	33,000 SCFM
HEAT TRANSFER AREA	2688 SQ FEET
MATERIAL	ALUMINUM
WEIGHT	2250 LBS

TABLE 5-2

COMPONENTS SUPPLIED WITH NITROGEN

CONDENSATE STORAGE TANKS
DEMINERALIZED WATER STORAGE TANKS
AUXILIARY BOILERS
FEEDWATER HEATERS
STEAM GENERATOR FEED PUMPS
MAIN GENERATOR
ELECTRICAL PENETRATION CANNISTERS
MSIV N_2 COMPRESSOR
SAFETY INJECTION TANKS
REACTOR COOLANT DRAIN TANK
STEAM GENERATORS
PRESSURIZER QUENCH TANK
VOLUME CONTROL TANK
DEGASSIFIER
WASTE GAS SURGE TANK
ION EXCHANGERS
WASTE EVAPORATORS
AFW ACCUMULATORS
POST LOCI SAMPLE SYSTEM
RAD CHEM GAS STORAGE LOCKERS

TABLE 5-3
PROBLEMS AND POSSIBLE CAUSES

PROBLEM	POSSIBLE CAUSES
INNER VESSEL SAFETY POPS	- Excessive tank pressure - Faulty safety valve
INNER VESSEL RUPTURE DISC BLOWS	- Faulty or corroded disc - Excessive tank Pressure - Faulty safety valve
EXCESSIVE TANK PRESSURE	- Insufficient consumption - Pressure Buildup regulator set too high. - Pressure Buildup regulator stuck open. - Economizer regulator set too high - Economizer regulator stuck open - Tank pressure gage wrong
TANK PRESSURE TOO LOW	- Pressure buildup manual valve shut. - Pressure buildup regulator set low - Pressure buildup regulator stuck closed. - Economizer regulator set low - Economizer regulator stuck closed tank; pressure gage reading wrong.

TABLE 5-3
PROBLEMS AND POSSIBLE CAUSES
(continued)

PROBLEM	POSSIBLE CAUSES
HEADER PRESSURE TOO LOW	- Line regulator set too low - Line regulator faulty - Tank pressure too low - Line pressure gage faulty
HEADER PRESSURE TOO HIGH	- Line regulator set too high - Line regulator faulty - Line pressure gage faulty
GAS TEMPERATURE TOO LOW	- Vaporizer inadequate for flow rate
CONTENTS GAGE READS TOO HIGH	- Leak in gas side pipe - Calibration incorrect - Faulty gage
CONTENTS GAGE READS TOO LOW	- By-pass valve not closed - Leak in liquid side piping - Calibration incorrect - Faulty gage

TABLE 5-3
PROBLEMS AND POSSIBLE CAUSES
(continued)

PROBLEM	POSSIBLE CAUSES
TANK PRESSURE GAGE	- Shut-off valve closed - Leak in gage piping - Faulty gage
LINE SAFETY POPS	- Liquid or very cold gas - trapped between closed valves *(nothing wrong safety designed to protect pipe under these conditions) - Faulty safety

* For additional Information see TECHNICAL MANUAL # 15-308-4 Section IV pages 1-6.

6.0 REFERENCES, DRAWINGS, AND SOURCES OF ADDITIONAL INFORMATION

This section lists in tabular format, references that are used in describing the system, operating.

Table 6-1
NITROGEN GAS SYSTEM REFERENCES

NORMAL OPERATING PROCEDURE	OI-4	
TECH. SPECS	None	
FSAR	Not Described	
TECHNICAL MANUALS	15308-004	
Operating and Maintenance Manual for Model 11300-400 Customer Station, MG INDUSTRIES PO. NO. 52240		
TECHNICAL DRAWINGS		
	<u>Bechtel</u>	<u>BG&E</u>
Piping and Instrument Diagram Nitrogen Gas System	OM 68	60-726-E
Piping and Instrument Diagram Well and Pretreated Water	OM 59	60-717-E (SH-1)
Piping and Instrument Diagram Instrument Air Unit-I	OM 53	60-712-E (SH-3)
Piping and Instrument Diagram Instrument Air Unit-II	OM 454	62-712-E (SH-3)
Piping and Instrument Diagram Safety Injection and Containment Spray	OM 74	60-731-E (SH-2 of 3)
Piping and Instrument Diagram Safety Injection and Containment Spray	OM 462	62-731-E (SH-2 of 3)
Piping and Instrument Diagram Reactor Coolant Waste Processing System	OM 77	60-734-E (SH-1, 2, 5, of 5)
Piping and Instrument Diagram Chemical Volume and Control System Unit-I	OM 73	60-730-E SH-1, 3 of 3)

Table 6-1
NITROGEN GAS SYSTEM
(continued)

	Bechtel	BG&E
Piping and Instrument Diagram Chemical Volume and Control System Unit-II	OM 461	62-730-E (SH-1 of 3)
Piping and Instrument Diagram Main Steam Unit-I	OM 35	60-700-E (SH-1 of 3)
Piping and Instrument Diagram Main Steam Unit-II	OM 36	62-700-E (SH-1 of 4)
Piping and Instrument Diagram Reactor Coolant System Unit-I	OM 72	60-729-E
Piping and Instrument Diagram Reactor coolant System Unit-II	OM 460	62-729-E
Piping and Instrument Diagram Nuclear Steam Sampling System	OM 66	60-724-E (SH-3 of 3)
Piping and Instrument Diagram MSIV Actuator Unit-I	OM 480	60-747-E
Piping and Instrument Diagram MSIV Actuator Unit-II	OM 483	62-747-E

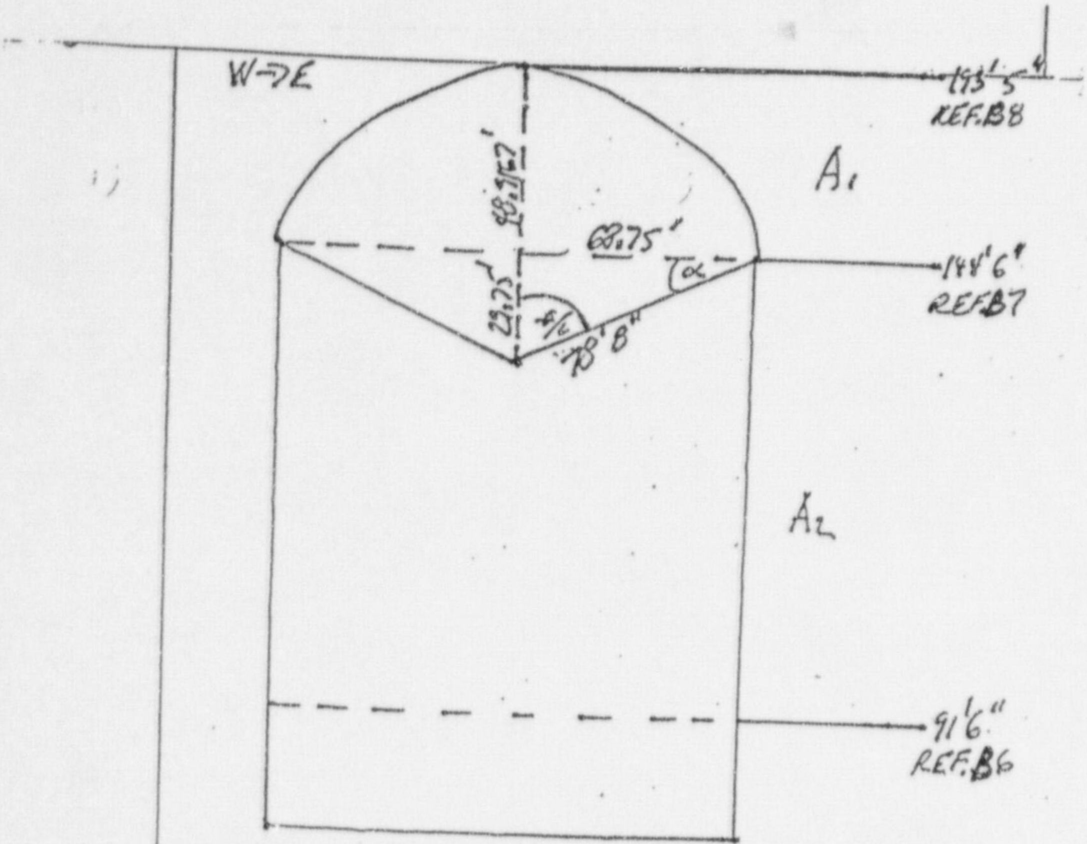
ADDITIONAL REFERENCES

Thermax Incorporated- ThermaFin Ambient Air Vaporizers

McGraw Hill, Dictionary of Science and Technical terms-
Q. 123 M34, 1989

McGraw Hill, Encyclopedia of Science and Technology
Q. 121 M3, 1982

ATTACHMENT G
CROSS SECTIONAL AREAS



$R = 78.6667'$ REF.B7

$C = 137.5'$ REF.B7

$\alpha = \arctan(29.75/68.75) = 23.3995°$

$\theta = 133.2011° = 2.3248$ rad

$h = 48.9167'$

$d = 29.75'$

$S = R\theta = 182.8841$

$A_1 = \frac{1}{2}(RS - Cd) = 5148.13\ ft^2$

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

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

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

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

TURBINE BUILDING: E→W

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

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

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

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

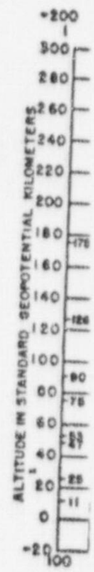
$A_{TOTAL} = 21016.56\ ft^2$

ATTACHMENT H
ATMOSPHERIC DENSITY VS ALTITUDE

STANDARD ATMOSPHERE (Continued)

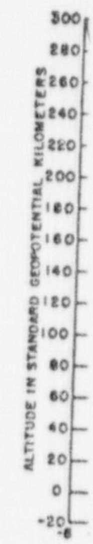
Abbreviated Metric Table of the U. S. Extension to the ICAO Standard Atmosphere

H m'	Z m	L_M °K m'$^{-1}$	T_M °K	T °K	M	P mb	ρ kg m^{-3}
−5,000	−4,996.070		320.66	320.66	28.966	1.7776×10^{3}	1.9312
		−0.0065					
0	0		288.16	288.16	28.966	1.01325×10^{3}	1.2250
		−0.0065					
11,000	11,019.067		216.66	216.66	28.966	2.2632×10^{2}	3.6391×10^{-1}
		zero					
20,000	20,063.124		216.66	216.66	28.966	5.4748×10^{1}	8.8034×10^{-2}
		zero					
25,000	25,098.710		216.66	216.66	28.966	2.4886×10^{1}	4.0016×10^{-2}
		+0.0030					
32,000	32,161.906		237.66	237.66	28.966	8.6776×10^{0}	1.2721×10^{-2}
		+0.0030					
47,000	47,350.101		282.66	282.66	28.966	1.2044×10^{0}	1.4845×10^{-3}
		zero					
53,000	53,445.620		282.66	282.66	28.966	5.8320×10^{-1}	7.1881×10^{-4}
		−0.0039					
75,000	75,895.488		196.86	196.86	28.966	2.452×10^{-2}	4.339×10^{-5}
		zero					
90,000	91,292.601		196.86	196.86	28.966	1.815×10^{-3}	3.213×10^{-6}
		+0.0035					
126,000	128,548.193		322.86	273.6	24.54	1.451×10^{-5}	1.566×10^{-8}
		+0.0100					
175,000	179,954.614		812.86	669.0	23.84	6.190×10^{-7}	2.655×10^{-10}
		+0.0058					
300,000	314,862.257		1,537.86	973.5	18.34	1.447×10^{-8}	3.279×10^{-12}



Abbreviated English Table of the U. S. Extension to the ICAO Standard Atmosphere

H ft'	Z ft	L_M °R ft'$^{-1}$	T_M °R	T °R	M	P lb ft^{-2}	ρ slugs ft^{-3}
−16,404.199	−16,391.307		577.188	577.188	28.966	3.7110×10^{3}	3.7457×10^{-3}
		−0.003566160					
0	0		518.688	518.688	28.966	2.1162×10^{3}	2.3769×10^{-3}
		−0.003566160					
36,089.239	36,151.798		389.988	389.988	28.966	4.7268×10^{2}	7.0611×10^{-4}
		zero					
65,616.798	65,823.897		389.988	389.988	28.966	1.1548×10^{2}	1.7251×10^{-4}
		zero					
82,020.997	82,344.849		389.988	389.988	28.966	3.1975×10^{1}	7.7644×10^{-5}
		+0.001645920					
104,986.877	105,518.055		427.788	427.788	28.966	1.8124×10^{1}	2.4682×10^{-5}
		+0.001645920					
154,199.475	155,348.103		508.788	508.788	28.966	2.5155×10^{0}	2.8803×10^{-6}
		zero					
173,884.514	175,346.523		508.788	508.788	28.966	1.2180×10^{0}	1.3947×10^{-6}
		−0.002139696					
246,062.992	249,000.945		354.348	354.348	28.966	5.121×10^{-2}	8.420×10^{-8}
		zero					
295,275.591	299,516.408		354.348	354.348	28.966	3.792×10^{-3}	6.234×10^{-9}
		+0.001920240					
413,385.827	421,746.041		581.148	492.4	24.54	3.031×10^{-5}	3.038×10^{-11}
		+0.005486400					
574,146.982	590,402.278		1,463.148	1,204.000	23.84	1.293×10^{-6}	5.147×10^{-13}
		+0.003182112					
984,251.969	1,033,012.654		2,768.148	1,752.000	18.3	3.023×10^{-8}	6.362×10^{-15}



ELEMENTS PRESENT IN SOLUTION IN SEA WATER EXCLUDING DISSOLVED GASES

Reprinted by permission of the publishers from "The Oceans" by Sverdrup, Johnson, and Fleming. Copyright, 1942, by Prentice-Hall, Inc.

Element	Concentration (grams/metric ton) or parts per million
Cl	18,980
Na	10,561
Mg	1,272
S	884
Ca	400
K	380
Br	65
C (inorganic)	28
Sr	13
(SiO_2)	0.01–7.0
B	4.6
Si	0.02–4.0
C (organic)	1.2–3.0
Al	0.16–1.9
F	1.4
N (as nitrate)	0.001–0.7
N (as organic nitrogen)	0.03–0.2
Rb	0.2
Li	0.1
P (as phosphate)	>0.001–0.10
Ba	0.05
I	0.05
N (as nitrite)	0.0001–0.05
N (as ammonia)	>0.005–0.05
As (as arsenite)	0.003–0.024
Fe	0.002–0.02
P (as organic phosphorus)	0–0.016
Zn	0.005–0.014
Cu	0.001–0.09
Mn	0.001–0.01
Pb	0.004–0.005
Se	0.004
Sn	0.003
Cs	0.002 (approximate)
U	0.00015–0.0016
Mo	0.0003–0.002
Ga	0.0005
Ni	0.0001–0.0005
Th	<0.0005
Ce	0.0004
V	0.0003
La	0.0003
Y	0.0003
Hg	0.00003
Ag	0.00015–0.0003
Bi	0.0002
Co	0.0001
Sc	0.00004
Au	0.000004–0.000008
Fe (in true solution)	$<10^{-8}$
Ra	2.10^{-11}–3.10^{-10}
Ge	Present
Ti	Present
W	Present
Cd	Present in marine organisms
Cr	Present in marine organisms
Tl	Present in marine organisms
Sb	Present in marine organisms
Zr	Present in marine organisms
Pt	Present in marine organisms

THE pH OF NATURAL MEDIA AND ITS RELATION TO THE PRECIPITATION OF HYDROXIDES

Reprinted from "Principles of Geochemistry" (1952) with the permission of Brian Mason, author, and John Wiley and Sons, publishers.

pH	Precipitation of hydroxides	Natural media	pH
11 } 10 }	Magnesium		11
		Alkali soils	10
9 } 8 }	Bivalent manganese		{ 9
		Seawater	{ 8
7	Bivalent iron	River water	7
6	Zinc copper	Rain water	6
5	Aluminum		5
4		Peat water	4
3 } 2 }	Trivalent iron	Mine waters	3
		Acid thermal springs	{ 2
1			{ 1

PROPERTIES OF THE EARTH'S ATMOSPHERE AT ELEVATIONS UP TO 160 KILOMETERS

The average atmosphere up to 160 km based on pressure and density data obtained on rocket flights above White Sands, New Mexico.
Havens, Koll, and LaGow, Journal of Geophysical Research, March, 1952.

Altitude km above sea level	Pressure mm Hg	Density gm/meters³	Temperatures °K (N_2, O_2) M = 29	Temperatures °K (N_2, O) M = 24	Velocity of Sound m. sec	Mean Free Path cm (N_2)
0	760	1220	290		345	6.5×10^{-6}
10	210	425	230		310	1.9×10^{-5}
20	42	92	210		295	8.6×10^{-5}
30	9.5	19	235		315	4.2×10^{-4}
40	2.4	4.3	260		325	1.8×10^{-3}
50	7.5×10^{-1}	1.3	270		330	6.1×10^{-3}
60	2.1×10^{-1}	3.8×10^{-1}	260		325	2.1×10^{-2}
70	5.4×10^{-2}	1.2×10^{-1}	210		295	6.6×10^{-1}
80	1.0×10^{-2}	2.5×10^{-2}	190		280	3.2×10^{-1}
90	1.9×10^{-3}	4.0×10^{-3}	210		295	2.0
100	4.2×10^{-4}	8.0×10^{-4}	240		315	10.0
110	1.2×10^{-4}	2.0×10^{-4}	270	220	330	40.0
120	3.5×10^{-5}	5.0×10^{-5}	330	270	370	1.5×10^{2}
130	1.5×10^{-5}	2.0×10^{-5}	390	320	400	4.0×10^{2}
140	7×10^{-6}	7.0×10^{-6}	450	370	430	1.0×10^{3}
150	3×10^{-6}	3.0×10^{-6}	510	420	460	2.5×10^{3}
160	2×10^{-6}	1.5×10^{-6}	570	470	480	5.0×10^{3}

VELOCITY OF SEISMIC WAVES

Depth km	Longitudinal or condensational km/sec.	Transverse or distortional km/sec.
0–20	5.4 –5.6	3.2
20–45	6.25–6.75	3.5
1300	12.5	6.9
2400	13.5	7.5

ATMOSPHERIC AND METEOROLOGICAL DATA

Total mass of the atmosphere, estimated by Ekholm, 5.2×10^{21} g, 11.4×10^{18} pounds, 5.70×10^{15} tons.
Evidence of extent: twilight, 63 km, 39 mi.: meteors, 200 km, 124 mi.: aurora 44–360 km, 27–224 mi.

*Distance to Earth.

STANDARD ATMOSPHERE

U. S. Extension to International Civil Aviation Organization Standard Atmosphere, 1958

The atmosphere was classified in 1958 into three altitude regions designated as

a. Standard 0 to 32 standard geopotential kilometers
b. Tentative 32 to 75 ,, ,, ,,
c. Speculative 75 to 300 ,, ,, ,,

Properties of the atmosphere were calculated as functions of geometric altitude as well as geopotential, the potential being established for the latitude where the acceleration of gravity has a sea-level value of 9.80665 meters per second per second. Symbols and abbreviations used in these tables are as follows:

H – Altitude in geopotential measure
L_M = Molecular-scale-temperature gradient
M = Mean molecular weight of air
m = Meter
m′ = Standard geopotential meter
P = Pressure
ρ = Mass density
T = Temperature in absolute thermodynamic scales
T_M = Molecular-scale temperature in absolute thermodynamic scales
Z = Altitude in geometric measure

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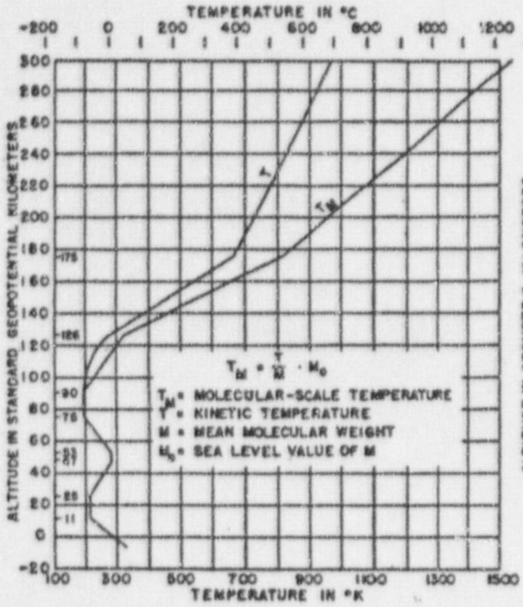
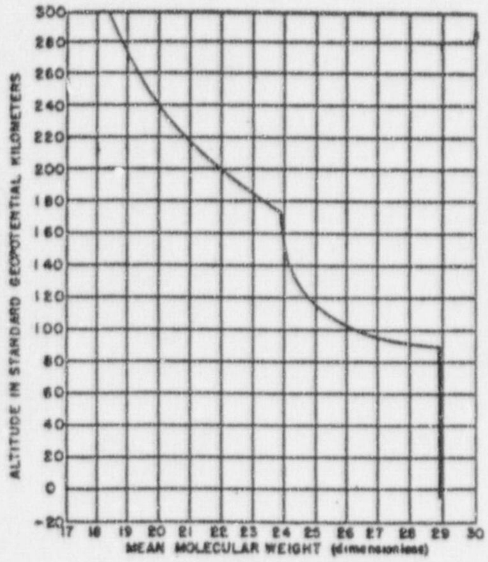
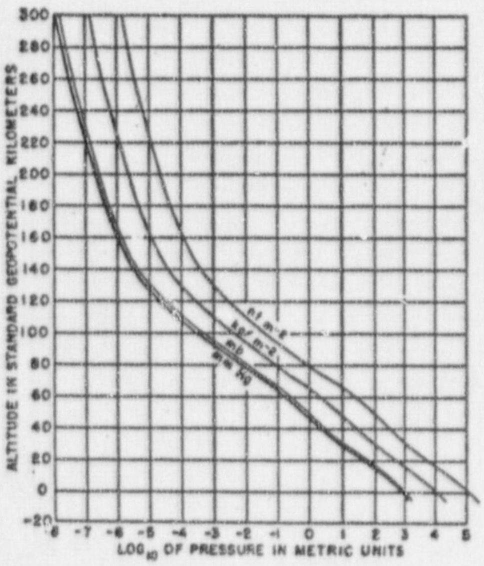


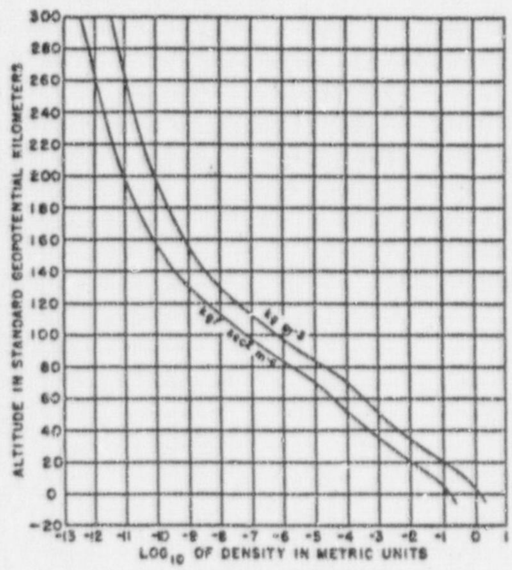
TEMPERATURE VS ALTITUDE



MEAN MOLECULAR WEIGHT VS ALTITUDE



PRESSURE VS. ALTITUDE



DENSITY VS. ALTITUDE

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SEA LEVEL ATMOSPHERIC COMPOSITION FOR A DRY ATMOSPHERE[a]

Constituent gas	Molecular fraction, %	Molecular weight ($O = 15.999_4$)
Nitrogen (N_2)	78.09	14.0067
Oxygen (O_2)	20.95	31.998_8
Argon (Ar)	0.93	39.94_8
Carbon dioxide (CO_2)	0.03	44.01
Neon (Ne)	1.8×10^{-3}	20.117_9
Helium (He)	5.24×10^{-4}	4.00260
Krypton (Kr)	1.0×10^{-4}	83.80
Hydrogen (H_2)	5.0×10^{-5}	2.016
Xenon (Xe)	8.0×10^{-6}	131.30
Ozone (O_3)	1.0×10^{-6}	47.999_4
Radon (Rn)	6.0×10^{-18}	222

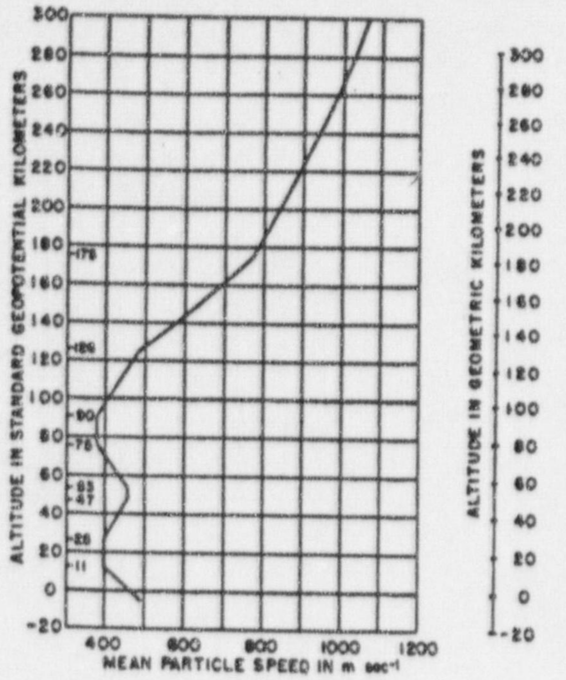
[a]These values are taken as standard and do not necessarily indicate the exact condition of the atmosphere. Ozone and radon particularly are known to vary at sea level and above, but these variations would not appreciably affect the value of M_O.

SEA LEVEL VALUES OF ICAO ATMOSPHERE

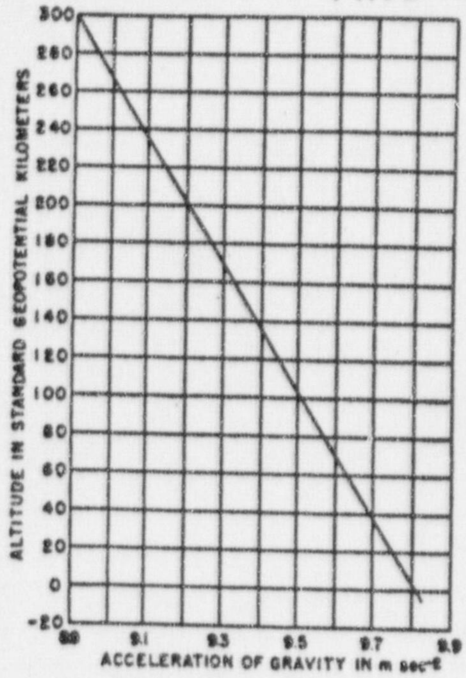
Property	Metric units
Collision frequency	6.9204049×10^{9} sec^{-1}
Conductivity, thermal	2.5339053×10^{-2} J m^{-1} sec^{-1} $(°K)^{-1}$
Conductivity, thermal	6.0532182×10^{-6} kcal m^{-1} sec^{-1} $(°K)^{-1}$
Conductivity, thermal	2.5838643×10^{-3} kgf[a] sec^{-1} $(°K)^{-1}$
Density, mass	1.2250140 kg m^{-3}
Density, mass	0.12491666 kgf sec^{2} m^{-4}
Gravitational acceleration	9.80665 m sec^{-2}
Kinematic viscosity	1.4607413×10^{-5} m^{2} sec^{-1}
Mean free path	6.6317223×10^{-8} m
Molar volume	23.645444 m^{3} $(kg\text{-}mol)^{-1}$
Molar volume	231.88259 m^{3} [(kgf sec^{2} m^{-1})-mol]
Molecular weight	28.966 (dimensionless)
Number density	2.5475521×10^{25} m^{-3}
Particle speed	458.94204 m sec^{-1}
Pressure	0.760 m Hg
Pressure	1,013.2500 mbar
Pressure	101,325.00 nt m^{-2}
Pressure	10,332.275 kgf m^{-2}
Scale height	8,434.4134 m
Sound speed	340,29205 m sec^{-1}
Specific weight	12.013284 kg m^{-2} sec^{-2}
Specific weight	1.2250140 kgf m^{-3}
Temperature	15.0°C
Temperature, absolute	288.16 K
Temperature, molecular scale	288.16 K
Viscosity, coefficient of	1.7894285×10^{-5} kg m^{-1} sec^{-1}
Viscosity, coefficient of	1.8247093×10^{-6} kgf sec m^{-2}

[a]kgf = kilogram (force)

STANDARD ATMOSPHERE (Continued)



MEAN PARTICLE SPEED
VS. ALTITUDE



ACCELERATION OF GRAVITY
VS. ALTITUDE

Angular Radius of Halos and Rainbows

Coronae due to small water drops	1° to 10°
Small halo, due to 60° angles of ice crystals	22°
Large halo, due to 90° angles of ice crystals	46°
Rainbow, primary	41° 20′
Rainbow, secondary	52° 15′

Solar Constant

The energy falling on one sq. cm. area at normal incidence, outside the earth's atmosphere, at the mean distance of the earth from the sun equals 2.00 small calories per minute. This value varies ± 2 %.

MEAN FREE PATH OF GASES

t = 20°C for data at pressures below 760mm Hg
t = 0°C for data at 760mm Hg

Gas	Pressure 1 mm Hg	0.1 mm Hg	0.01 mm Hg	0.001 mm Hg	760 mm Hg
Argon	4.73×10^{-5} m	4.73×10^{-4} m	4.73×10^{-3} m	4.73×10^{-2} m	6.20×10^{-8} m
Helium	13.32	13.32	13.32	13.32	13.32
Hydrogen	8.81	8.81	8.81	8.81	8.81
Krypton	3.63	3.63	3.63	3.63	3.63
Neon	9.4	9.4	9.4	9.4	9.4
Nitrogen	4.5	4.5	4.5	4.5	
Oxygen	4.82	4.82	4.82	4.82	
Xenon	2.62	2.62	2.62	2.62	6.33

COMPONENTS OF ATMOSPHERIC AIR
(Exclusive of water vapor)

Constituent	Content (per cent) by volume	Content (ppm) by volume
N_2	78.084 ± 0.004	
O_2	20.946 ± 0.002	
CO_2	0.033 ± 0.001	
Ar	0.934 ± 0.001	
Ne		18.18 ± 0.04
He		5.24 ± 0.004
Kr		1.14 ± 0.01
Xe		0.087 ± 0.001
H_2		0.5
CH_4		2
N_2O		0.5 ± 0.1

Gas	Collision frequency 20° C	Molecular diameter, cm From viscosity	From van der Waal's equation	From heat condustivity
Ammonia	9150×10^6	2.97×10^{-8}	3.08×10^{-8}	....
Argon	4000	2.88	2.94	2.86×10^{-8}
Carbon monoxide	5100	3.19	3.12	....
Carbon dioxide	6120	3.34	3.23	3.40
Helium	4540	1.90	2.65	2.30
Hydrogen	10060	2.40	2.34	2.32
Krypton	....	....	(2.69)	3.14
Mercury	....	....	3.91	....
Nitrogen	5070	3.15	3.15	3.53
Oxygen	4430	2.98	2.93	....
Xenon	....	....	4.02	3.42