



Crystal River Nuclear Plant  
Docket No. 50-302  
Operating License No. DPR-72

February 15, 2001  
3F0201-11

Document Control Desk  
U. S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

**Subject:** Response to NRC Request for Supporting Calculations Related to License Amendment Request No. 262

**Reference:** FPC to NRC letter 3F1000-08, dated October 8, 2000, License Amendment Request No. 262, Revision 0, " Alternative Source Term and Control Room Emergency Ventilation System"

Dear Sir:

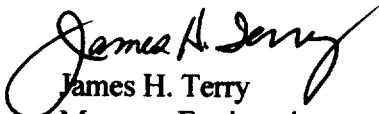
By Reference 1, Florida Power Corporation (FPC) requested changes to the CR-3 Improved Technical Specifications (ITS) based on the results of revised dose calculations for CR-3 design basis radiological accidents using an alternative source term.

As requested by the NRC Project Manager, FPC is providing the attached calculations, which are identified as References 1 and 7 in LAR No. 262.

This submittal contains no new regulatory commitments.

If you have any questions regarding this submittal, please contact Mr. Sid Powell, Supervisor, Licensing and Regulatory Programs, at (352) 563-4883.

Sincerely,

  
James H. Terry  
Manager Engineering

JHT/jal

Accol

Attachment 1: FPC Calculation M97-0109 R/1 (SL-9929-M-0008 R/1), "Toxic Gas Analysis"

Attachment 2: FPC Calculation M-00-0002, "CR3 Control Room Chlorine Concentration for a Transportation Accident"

xc: Regional Administrator, Region II  
Senior Resident Inspector  
NRR Project Manager



# INTEROFFICE CORRESPONDENCE

A-C-XMTL.FRM

Nuclear Engineering

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SUBJECT: Crystal River Unit 3  
Quality Record Transmittal - Analysis/Calculation  
TO: Records Management - NR2A

The following analysis/calculation package is submitted as the QA Record copy:

DOCNO (FPC DOCUMENT IDENTIFICATION NUMBER) M97-0109	REV. 1	SYSTEM(S) AH-XK	TOTAL PAGES TRANSMITTED 261
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TITLE

Control Complex Habitability Evaluation for Postulated Onsite Chemical Release of Chlorine and Sulfur Dioxide

KWDS (IDENTIFY KEYWORDS FOR LATER RETRIEVAL)

Control Complex, Habitability, Toxic Gas, Chlorine, Sulfur Dioxide, Chemical, Release

DXREF (REFERENCES OR FILES - LIST PRIMARY FILE FIRST)

MAR 97-07-05-01

MAR 97-07-05-02

VEND (VENDOR NAME)

Sargent & Lundy

VENDOR DOCUMENT NUMBER (DXREF)

SL-9929-M-0008 / Rev 1

SUPERSEDED DOCUMENTS (DXREF)

See Comments Below

TAG

AHFL-4A

AH-652-CE

AHFL-4B

AH-653-CE

AHF-18A

AH-648-CE

AHF-18B

AH-649-CE

PART NO.

COMMENTS (USAGE RESTRICTIONS, PROPRIETARY, ETC.)

See attached IOC NOE97-2315 for comments concerning usage. Rev 0 was never entered into FPC files.

This Calculation is part of the overall Control Complex Emergency Ventilation System (CREVS) upgrade.

performed by MARs 97-07-05-01 and -02. Developed under the 11D, Restart Issue R-12.

## NOTE:

Use Tag number only for valid tag numbers (i.e., RCV-8, SWV-34, DCH-99); otherwise, use Part number field (i.e., CSC14599, AC1459). If more space is required, write "See Attachment" and list on separate sheet.

## \*\*FOR RECORDS MANAGEMENT USE ONLY\*\*

Quality Record Transmittal received and information entered into SEEK.

Entered by: \_\_\_\_\_ Date \_\_\_\_\_

(Return copy of Quality Record Transmittal to NOE Support Specialist.)

DESIGN ENGINEER

D.J. Wilkinson

DATE

12/20/97

VERIFICATION ENGINEER

N/A

DATE

SUPERVISOR, NUCLEAR ENG

C.L. Miller

DATE

12/20/97

cc: Nuclear Projects (If MAR/CGWR/PEERE  
Return to Service Related) ☒ Yes ☐ No  
Supervisor, Config. Mgt. Info.  
Mgr., Nucl. Operations Eng. (Original) w/attach

Calculation Review form Part III actions required ☐ Yes ☒ No  
(If Yes, send copy of the form to Nuclear Regulatory Assurance and a  
copy of the Calculation to the Responsible Organization(s) identified in  
Part III on the Calculation Review form.)



# CALCULATION REVIEW

CALC-REV.FRM

Page 1 of 2

CALCULATION NO./REV.

M97-0109/Rev1 Control Room Habitability Evaluation for Postulated Onsite Chemical Release Of Chlorine and Sulfur Dioxide

**PART I - DESIGN ASSUMPTION/INPUT REVIEW: APPLICABLE** ☒ Yes ☐ No

The following organizations have reviewed and concur with the design assumptions and inputs identified for this calculation:

Nuclear Plant Technical Support  
System Engr

Ken Anderson  
Signature/Date

*K. L. Anderson* 12-20-97

Nuclear Plant Operations  
OTHER(S)

Paul McKee  
Signature/Date

*Paul McKee* 12/20/97

Signature/Date

Signature/Date

**PART II - RESULTS REVIEW: APPLICABLE** ☒ Yes ☐ No

The following organizations have reviewed and concur with the results of this calculation and understand the actions which the organizations must take to implement the results.

Nuclear Plant Technical Support  
System Engr

Ken Anderson  
Signature/Date

*K. L. Anderson* 12-20-97

Nuclear Plant Operations

Paul McKee  
Signature/Date

*Paul McKee* 12/20/97

Nuclear Plant Maintenance

☐ Yes ☒ N/A

Signature/Date

Nuclear Licensed Operator Training

☐ Yes ☒ N/A

Signature/Date

Manager, Site Nuclear Services

☐ Yes ☒ N/A

Signature/Date

Sr. Radiation Protection Engineer

☐ Yes ☒ N/A

Signature/Date

Nuclear Plant EOP Group

☐ Yes ☒ N/A

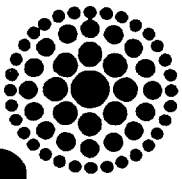
Signature/Date

OTHER:

Signature/Date







**Florida  
Power**  
CORPORATION

# INTEROFFICE CORRESPONDENCE

Nuclear Operations Engineering  
OFFICE

NA1E  
MAC

3576  
TELEPHONE

SUBJECT: **Crystal River Unit 3**  
**Interim use of Control Complex Calculations**

TO: **Calculation Files**

DATE: **November 13, 1997**  
**NOE 97-2315**

The following list identifies Control Complex related calculations that will be revised or superseded by new calculations dependent on NRC approval of proposed licensing submittals described in 3F1197-09. Any changes to the calculations listed must be reconciled in entirety between the old and new licensing basis until the new submittals are approved by the NRC and the old calculations are superseded.

New Calculation	Revised/superseded Calculation
M97-0109 R0	I86-0006 R0
	I86-0007 R0
	I86-0008 R0
	I86-0010 R0
	I87-0005 R2
	I87-0007 R0
	I89-0053 R3
	M96-0023 R0
M97-0110 R0	M95-0014 R0
	M96-0015 R0
	I86-0003 R8 *
M97-0111 R0	I86-0009 R0
	M96-0024 R0

\* Partial superseding. The calculation will be revised to remove portions which are covered in the new calculation for control room dose, but the offsite dose portion will remain in I86-0003.

A copy of this memorandum will be placed in all of the calculations contained in the table. When the proposed submittal to the NRC is accepted, appropriate revisions will be made to the calculations shown in the Table as well as to the EDBD's, FSAR and other documents.

  
H. Oates 11/13/97

cc:

M. Loehr  
Mike Clary  
B. Kingery  
Craig Miller  
Syd Powell  
Records Management  
MSA File

# Sargent & Lundy<sup>LLC</sup>

S. M. Malak  
Project Manager  
312-269-6867  
312-269-2208 Fax

December 5, 1997  
Project No. 09929-036  
Letter No. SLFPC-452  
File No. 2.2

Florida Power Corporation  
Crystal River Nuclear Station Unit 3

Transmittal of Control Room Toxic Gas Calculation

References: 1. Engineering and Related Services Agreement Contract No. N01254AD  
2. Work Authorization No. 55, Rev. 1

Mr. W. W. Nisula  
Contract Manager  
Florida Power Corporation  
Crystal River Station  
15760 West Power Line Street  
Crystal River, Florida 34428-6708

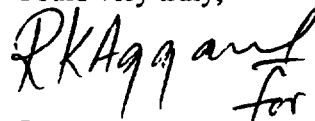
Attention: Mr. Wilkinson

Dear Mr. Nisula:

Enclosed please find the original Calculation No. SL-9929-M-0008, Rev. 1, "Control Complex Habitability Evaluation for Postulated Onsite Chemical Release of Chlorine and Sulphur Dioxide."

If you have any questions, please contact Mr. R. Aggarwal at (312) 269-6734, Mr. H. S. Taylor at (312) 269-6371 or me.

Yours very truly,

  
S. M. Malak  
Project Manager

SMM:RKA:mma  
Enclosure  
Copies:  
Distribution on Page 2

Mr. W. W. Nisula  
Florida Power Corporation

December 5, 1997  
Project No. 9929-036  
Letter No. SLFPC-452  
Page 2

**Copies:**

A. Petrowsky (1/0)  
M. D. Clary (1/0)  
Mr. Wilkinson (1/1)  
B. A. Erler (1/0)  
H. S. Taylor (1/0)  
E. Zakis (1/0)  
R. K. Aggarwal (1/1)  
M. C. Handrick (1/1)  
J. L. Philipps (1/0)  
C. A. Sward (1/0)  
B. J. Van Sant (1/0)  
File No. 2.2 (1/1)  
J:\SEABU\FPC\LETTERS\FPC-452.doc

## Design Information Transmittal

<input checked="" type="checkbox"/> SAFETY-RELATED	<input type="checkbox"/> NON-SAFETY-RELATED	DIT No. <u>DIT-CR-0068</u>	
Client: <u>Florida Power Corporation</u>		Page <u>1</u> of <u>1</u>	
Station: <u>Crystal River</u> Unit(s) <u>3</u>		To: <u>M. Clary FPC</u>	
Project No(s): <u>9929-036</u>			
Subject: <u>Transmittal of Calculation SL-9929-M-0008 Rev. 1</u>			
MODIFICATION OR DESIGN CHANGE NUMBER(S): <u>N/A</u>			
<u>Mark Handrick</u> Preparer (Please print name)	<u>PSED</u> Division	<u>Mark Handrick</u> Preparer's Signature	<u>12/5/97</u> Date
<b>STATUS OF INFORMATION:</b> (This information is approved for use. Design information, approved for use, that contains assumptions or is preliminary or requires further verification (review) shall be so identified.) <u>Approved For Use</u>			
<b>IDENTIFICATION OF THE SPECIFIC DESIGN INFORMATION TRANSMITTED AND PURPOSE OF ISSUE</b> (List any supporting documents attached to DIT by its title, revision and/or issue date, and total number of pages for each supporting document)  <i>This DIT transmits approved Sargent &amp; Lundy Calculation SL-9929-M-0008, Revision 1, entitled "Control Complex Habitability Evaluation for Postulated Onsite Chemical Release of Chlorine and Sulfur Dioxide", dated December 5, 1997. This calculation is for FPC's use, for incorporation into FPC design basis as appropriate, and for QA records retention.</i>			
<b>SOURCE OF INFORMATION:</b>			
Calc. no. <u>SL-9929-M-0008</u>	Rev. <u>1</u> Rev. and/or date	Report No. <u>N/A</u>	<u>N/A</u> Rev. and/or date
Other			
Distribution: <u>S. M. Malak - 24</u> <u>H. S. Taylor - 24</u> <u>R. J. Peterson - 23</u>			
File No.: <u>6.2</u>			

# ISSUE SUMMARY GES-320.10.4

DESIGN CONTROL SUMMARY DESIGN VERIFICATION - PAGE 1			
CLIENT:	Florida Power Corporation	UNIT NO.:	3
PROJECT NAME:	Crystal River		
PROJECT NO.:	09929-036		
CALC. NO.:	SL-9929-M-0008	<input checked="" type="checkbox"/> SAFETY-RELATED	
TITLE:	Control Complex Habitability Evaluation for Postulated Onsite Chemical Release of Chlorine and Sulfur Dioxide		QA
STATUS:	Verified		
EQUIPMENT NO.:		<input type="checkbox"/> NON-SAFETY-RELATED	
		COMMENT NO.	SERIAL NO.
IDENTIFICATION OF PAGES ADDED/REVISED/SUPERSEDED/VOIDED & REVIEW METHOD			
Revision 1: Revised pages 1-3, 10-13, 24-30, 32-37. Deleted pages 38-48. Pages A1-A3 unchanged Revised pages B1-B113, Deleted pages B114-B115. Pages C1-C14 unchanged Revised pages D1-D4. Revised page E32, <i>E2 M. H.</i> Revised pages F1-F6, Deleted pages F7-F19 Revised pages G2-G3, Deleted pages G4-G10 Added pages H1-H2 Main Body - 37 pages, Total Attachments - 177 pages			
REVIEW METHOD: Detailed Review		REV. 1	
		DATE FOR REV.:	
PREPARER	Mark Handrick <i>Mark Handrick</i>	DATE: 12/5/97	
REVIEWER	Chad J. Mikts <i>Chad J. Mikts</i>	DATE: 12/5/97	
<i>The reviewer's signature indicates compliance with GES 320.10 and the verification of the following minimum items: correctness of math for hand prepared calculations, appropriateness of input data, appropriateness of assumptions, and appropriateness of the calculation method.</i>			
APPROVER	Robert J. Peterson <i>Robert J. Peterson</i>	DATE: 12/5/97	
IDENTIFICATION OF PAGES ADDED/REVISED/SUPERSEDED/VOIDED & REVIEW METHOD			
REVIEW METHOD:		REV.	
		DATE FOR REV.:	
PREPARER		DATE:	
REVIEWER		DATE:	
<i>The reviewer's signature indicates compliance with GES 320.10 and the verification of the following minimum items: correctness of math for hand prepared calculations, appropriateness of input data, appropriateness of assumptions, and appropriateness of the calculation method.</i>			
APPROVER		DATE:	



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## 1.0 Purpose/Objective

The purpose of this calculation is to evaluate the toxic gas concentrations in the Crystal River Unit 3 (CR-3) main control room following a postulated onsite release of either chlorine or sulfur dioxide (non-concurrent). This calculation will determine the largest amounts of chlorine and sulfur dioxide that can be stored onsite, assuming no isolation of CR-3's control complex. This quantity is determined by comparing the control complex concentration two minutes after nasal detection to the toxicity limit for each chemical. This calculation also quantifies the required response time of the automatic isolation system under a postulated limiting onsite release of chlorine or sulfur dioxide, assuming sensor detection of the release at the control complex air intake.

This calculation revision incorporates verified wind tunnel testing data from Cermak Peterka Petersen, Inc. (CPP), which replaces the unverified input used in Revision 0. Also, the control complex inleakage rate used in the analysis is 435 cfm, per Reference 5.26, replacing the value of 355.3 cfm used in Revision 0.



## 2.0 Methodology/Acceptance Criteria

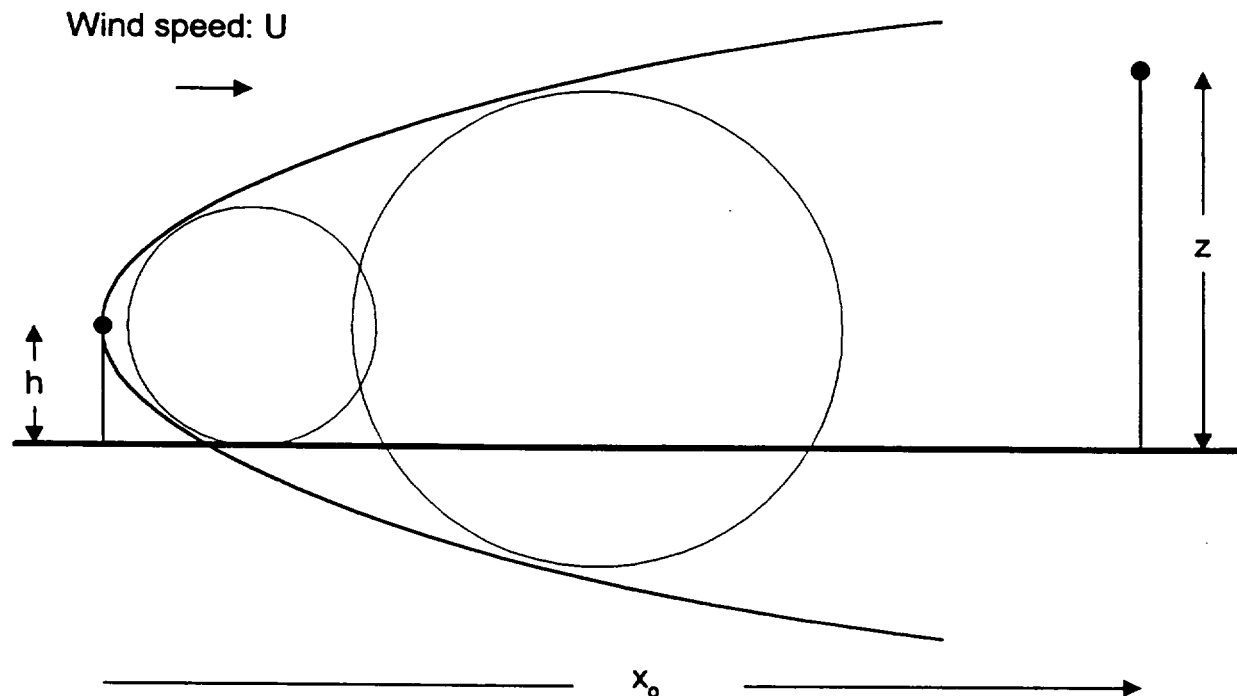
### 2.1 Methodology

Per Reference 5.1, the maximum concentration accident is considered to be the instantaneous release of the total contents of the largest chemical container stored onsite. In order to determine the control room concentration following such a release, a FORTRAN computer code is written which will model the chemical release transient. The validation of the computer code is provided in Attachment E, and is performed per Sargent & Lundy General Engineering Standards. The computer model developed in this calculation will evaluate three processes: (i) the flashing of the released chemical to form a gas, including both the instantaneous "puff" release and the continued boiloff of the liquid spill contributing to a vapor "plume" release, (ii) the dilution of the gas as it disperses through the atmosphere, moving towards the control complex air intake, and (iii) the infiltration of the chemical gas into the control room.

The computer runs are made on Sargent & Lundy's DECstation 5000 workstation under the DEC Ultrix version of the UNIX operating system.

The instantaneous flashing of the released chemical is based on the temperature difference between the chemical's boiling temperature and the ambient temperature. Higher ambient temperatures result in larger flashing fractions, therefore this calculation will assume that the chemical release occurs during the summer months, when the ambient temperature is at its maximum value. The initial mass of chemical that flashes is then modeled as a spherical puff, which disperses while being blown through the atmosphere toward CR-3's control complex air intake. The diffusion model for this puff is taken from Reference 5.2, which assumes a Gaussian distribution of the moving puff, with the puff centerline assumed to remain in-line with the control complex air intake. A schematic representation of the puff model is shown on the following page.

## Diffusion Model per the Methodology of NUREG-0570



where:

$h$  = effective above-ground elevation of the source

$z$  = effective above-ground elevation of the detector

$x_0$  = distance from source to the detector

$U$  = wind speed

To model heavier than air gases, such as chlorine and sulfur dioxide, Reference 5.2 recommends that the values of  $h$  and  $z$  each be set to zero. Setting  $h = 0$  eliminates the apparent mass flux into the ground, as suggested by the schematic above. Setting  $z = 0$  conservatively accounts for building effects. An example of a building effect would be a high ground level concentration of gas being swept up the side of a building to the control complex air intake. This methodology generally results in conservative chemical concentrations at the air intake. The conservatism inherent in the Gaussian model described above is recognized in Reference 5.3, and an alternative calculation for the dispersion of heavier than air gases is provided by Ref. 5.3. In the alternative model, the puff is considered to be dispersed uniformly in a vertical layer extending from grade

elevation to the control complex air intake. The concentration at the air intake is also determined using this methodology, and the minimum puff concentration obtained using each model is selected.

The amount of puff dilution that occurs as the puff moves toward the detector is modeled by selecting the appropriate concentration standard deviations in the three coordinate directions. These standard deviations, hereafter called dispersion coefficients, are dependent upon the value of  $x_0$ , and on the Pasquill atmospheric stability class. The choice of atmospheric stability class is prescribed by Reference 5.1, which states that the appropriate class is based on the worst five percentile meteorology observed at the site according to the  $\Delta T$  method. Reference 5.11 provides this data for the Crystal River site. The most stable class, type G, occurs 5.66 percent of the time based on an annual average. During the summer months (June - September) however, type G is only observed approximately three percent of the time. Since this calculation will conservatively use summer temperatures to compute the initial flashing fraction, as well as the remaining liquid spill evaporation rate described below, it is felt that atmospheric class F is an appropriate choice, and still contains the conservatism implied by Reference 5.1.

In addition to the initial puff, a continuous chemical plume is also modeled as moving toward the air intake. The release rate attributed to the plume is calculated based on evaporation of the remaining liquid due to three heat transfer processes: i) conduction from the ground, ii) solar radiation, and iii) forced convection due to wind. The evaporation rate is also dependent upon the surface area of the liquid spill. This surface area is calculated per the methodology of Reference 5.2. If the spill area is limited by a berm or a dike, then this value is credited.

Other factors that are employed in the model include plume meander and building wake effects, both of which act to reduce the calculated chemical concentration at the control complex air intake. Incorporation of these effects is done per the methodology of Reference 5.4. Meander factors are developed from test data, which have shown that at light wind speeds, the measured effluent concentrations are usually substantially lower than those predicted by the use of the Pasquill model. Building wake effects are applicable for releases through vents or other building penetrations. These effects will be extended to those cases where large buildings are located very close to, and downwind of the source location. The meander and wake effects are also extended to the puff concentration calculation; per the guidance of Reference 5.1, which allows credit for puff building wake effects and other dispersive phenomena.

After the time-dependent concentration at the control complex air intake is calculated as the sum of the puff and plume concentrations, the control complex concentration is computed as a function of the ventilation rate, inleakage rate, and control complex volume per the requirements of Reference 5.1. The computer code also models the time-dependency of the detection and isolation logic, in terms of system response time from sensor detection to control complex isolation, when calculating control complex concentrations for the automatic isolation scenarios.

In compliance with Reference 5.1, the control room concentration is obtained at various wind speeds, and the value which results in the highest concentration is selected.

## 2.2 Acceptance Criteria

The limits on the mass of chemicals stored onsite are determined such that the control complex concentration two minutes after nasal detection, without automatic isolation of the control complex, remain below the toxicity limit for each particular chemical. These toxicity limits are 15 ppm for chlorine, and 36 ppm for sulfur dioxide per Reference 5.10.

For those chemicals which result in a need for automatic isolation by exceeding the mass limits described above, response time of the isolation system must be fast enough to prevent the control complex concentration from exceeding the toxicity limit.

### 3.0 Assumptions

#### Atmospheric Conditions

- 3.1 The chemical release is assumed to travel in a straight line from the source (tank) to the control complex air intake.
- 3.2 Design temperature values during the summer for the Crystal River site are assumed to be the same as those for Tampa, FL. Summer conditions consistent with the worst five percentile meteorology are chosen to maximize the initial flashing of chemical release and liquid evaporation rate, conservatively maximizing the chemical concentrations of the puff and plume respectively.
- 3.3 The limiting atmospheric stability class is assumed to be Pasquill Type F, consistent with the worst five percentile meteorology observed during the summer months at the Crystal River site. Per Reference 5.11, the only notable exceptions to this occur during the winter months, i.e. November through March, when the atmospheric temperature is much less than that observed during the summer.
- 3.4 It is assumed that the temperature of the earth is the same as the ambient air temperature. The earth temperature is used to compute conduction heat transfer from the ground to the liquid spill when calculating the spill evaporation rate.

#### Building Wake Factors and Meander Effects

- 3.5 A building wake factor of 3.0 is assumed for the chlorine source at Crystal River Units 4/5. This is based on Figure 1 of Reference 5.16, using a distance of 3600 feet and a projected building cross-sectional area of 8289.7 m<sup>2</sup> (per Design Inputs 4.2.2 and 4.2.4).
- 3.6 A building wake factor of 3.0 is assumed for the sulfur dioxide source at Crystal River Units 1/2. This is based on Figure 1 of Reference 5.16, using a distance of 750 feet (per Design Input 4.3.2). At this distance, the wake factor is independent of building cross-sectional area.
- 3.7 A building wake factor of 2.0 is assumed for the chlorine and sulfur dioxide sources at the Helper Cooling Towers. Per References 5.13d, 5.13e, and 5.13f, the Cl<sub>2</sub> and SO<sub>2</sub> sources lie directly upstream of the Water Treatment Building, and just west of the Helper Cooling Towers 1 and 2. This configuration results in the chemical dispersion path being partially obstructed, allowing for turbulent dilution of the chemical release. During operation, the Helper Cooling Towers would provide an additional barrier to dispersion in the form of a water vapor shield. When not in operation, a 'chimney' effect would likely lead to increased mixing of the chemical release and incoming air. Since the effective projected area of these obstructions is difficult to quantify, the wake factor of 2.0 is



chosen, as this is the midpoint of the allowable range of 1 to 3. It is judged that this represents an appropriate value of building wake factor for use at the Helper Cooling Towers.

- 3.8 Meander effects are assumed applicable to both the  $x$  and  $y$  coordinate directions. This is judged appropriate per the discussion on page II-1 of Reference 5.5, which states that the meander effect will reduce the lateral concentration up to an  $180^\circ$  arc due to increased horizontal spreading. These effects are assumed applicable to the puff as well as the plume, per the guidance of Reference 5.1 which allows credit for puff dispersive phenomena.

#### Chemical Release Parameters for Chlorine

- 3.9 Thick-walled copper tubing of 3/8 inch outer diameter is assumed for the connection of the one-ton chlorine containers to the piping system at CR Units 4/5, per the discussion of Section 2.8.5 of Reference 5.14.
- 3.10 The vapor pressure of chlorine at  $90^\circ\text{F}$  is assumed to be 123 psig (137.7 psia), consistent with Figure 9.1 of Reference 5.14.
- 3.11 The leak rate of the intact one-ton chlorine containers at CR Units 4/5 is calculated based on the assumption of isentropic critical gas flow. This is justified, as the chlorine containers are generally stored in the upright position, per Section 2.8.8 of Reference 5.14, and the vapor/liquid interface would be below the discharge valve location. The calculated vapor release rate is then added directly to the evaporative plume, conservatively maximizing the plume concentration.

#### Chemical Release Parameters for Sulfur Dioxide

- 3.12 The leak rate of the 45 ton sulfur dioxide tank at CR Units 1/2 is calculated based on the assumption of failure of the 2 inch piping at the fill connection and/or its associated ball valve, per Reference 5.13h. Since the fill location is below the centerline of the tank, the leak rate is calculated based on the assumption of critical liquid flow, per the methodology of Reference 5.24. The liquid discharge is then assumed to partially flash to vapor, adding directly to the plume concentration. The remaining liquid discharge is available for evaporation, assuming a liquid pool of 1 cm thickness, per the methodology of Reference 5.2.
- 3.13 Schedule 40 piping is assumed for the piping connections at the  $\text{SO}_2$  tank at CR Units 1/2. This assumption leads to a conservatively higher calculated leak rate than the use of Schedule 80 piping.

## 4.0 Design Input

### 4.1 General

- 4.1.1 The CR-3 control complex volume is taken as 364,922 ft<sup>3</sup>, per Reference 5.6. This includes the HVAC equipment room.
- 4.1.2 The CR-3 control complex ventilation rates before and after isolation are 5,700 cfm and 435 cfm respectively, per References 5.7 and 5.26 respectively.
- 4.1.3 The CR-3 control complex air intake is located 26.5 meters above grade, per Reference 5.7.
- 4.1.4 The 5% design dry bulb temperature for Tampa during the summer is 90 °F, per Reference 5.12.
- 4.1.5 Physical properties of Chlorine (Cl<sub>2</sub>) and Sulfur Dioxide (SO<sub>2</sub>) per Reference 5.2:

<u>Property</u>	<u>Value (units)</u>	<u>Value (units)</u>
	Chlorine	Sulfur Dioxide
Molecular Weight	70.9 gm/g-mole	64.1 gm/g-mole
Boiling Temperature	-34.1 °C	-10.0 °C
Density of saturated liquid (based on water density of 1000 kg/m <sup>3</sup> )	1570 kg/m <sup>3</sup>	1460 kg/m <sup>3</sup>
Specific Heat	0.226 cal/gm-°C	0.361 cal/gm-°C
Latent Heat of Vaporization	68.8 cal/gm	92.8 cal/gm

- 4.1.6 Per Reference 5.20, the inner diameter of 3/8-inch thick-walled copper tubing is 0.402 inches.

### 4.2 Chlorine Parameters

- 4.2.1 Per Reference 5.9, a 17 ton chlorine tank is located at the Helper Cooling Towers, 3,400 feet away from the Unit 3 control complex air intake.
- 4.2.2 Per Reference 5.8, eight chlorine containers at one ton each, are stored at CR Units 4/5 at a distance of 3,600 feet. Only four of these containers are in service at any one time.
- 4.2.3 The chlorine storage location at CR Units 4/5 is directly behind a hyperbolic cooling tower, per Reference 5.13a.

4.2.4 The cross-sectional area of the hyperbolic cooling towers at CR Units 4/5, normal to the direction of wind travel, is 8,289.7 m<sup>2</sup> per References 5.13b and 5.13c. This is a conservative minimum value based on the inner diameter at the top of the cooling tower.

4.2.5 The setpoint for the chlorine detectors at the control complex intake is less than or equal to 5 ppm, per Reference 5.9.

4.2.6 The toxicity limit for chlorine exposure for a time duration of two minutes or less is 15 ppm, per Reference 5.10.

4.2.7 The nasal detection concentration for chlorine is 3.5 ppm, per Reference 5.15.

#### 4.3 Sulfur Dioxide Parameters

4.3.1 Per Reference 5.9, a 50 ton sulfur dioxide tank is located at the Helper Cooling Towers, 3,400 feet away from the CR Unit 3 control complex air intake.

4.3.2 Per References 5.13h and 5.7, a 45 ton sulfur dioxide tank is located at Crystal River Units 1/2, 750 feet away from the CR Unit 3 control complex air intake. A dike surrounding the SO<sub>2</sub> tank at CR Units 1/2 restricts the area of the spill to 55.75 m<sup>2</sup>, per Reference 5.7.

4.3.3 Per Reference 5.8 sulfur dioxide is stored at CR Units 4/5 in one ton containers at a distance of 3600 feet from the CR 3 air intake.

4.3.4 The setpoint for the sulfur dioxide detectors at the control complex intake is less than or equal to 2.4 ppm, per Reference 5.9.

4.3.5 The toxicity limit for sulfur dioxide exposure for a time duration of two minutes or less is 36 ppm, per Reference 5.10.

4.3.6 The nasal detection concentration for sulfur dioxide is 3.0 ppm, per Reference 5.15.

#### 4.4 Wind Tunnel Testing Data

Wind tunnel testing data provided by Cermak Peterka Petersen, Inc. (CPP) are used to evaluate the degree of conservatism used in the analytical model developed in this calculation. Specifically, CPP modeled the actual building geometry of Crystal River Units 1, 2, and 3, and the accident scenario representative of the SO<sub>2</sub> tank failure at CR Units 1/2, releasing 30 tons of SO<sub>2</sub> (Reference 5.25). Summary results from the CPP report are included in Attachment F.



## 5.0 References

- NRC DJW 12/11/97*
- 5.1 U.S. Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release", June 1974.
- 5.2 NUREG-0570, "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release", James Wing, June 1979.
- 5.3 NUREG/CR-3786, "A Review of Regulatory Requirements Governing Control Room Habitability Systems", Mark J. Jacobus, August 1984.
- NRC DJW 12/11/97*
- 5.4 U.S. Regulatory Guide 1.145, Rev. 1, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants", November 1982.
- 5.5 NUREG/CR-2260, Technical Basis for Regulatory Guide 1.145, 'Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants', W. G. Snell, R. W. Jubash of NUS Corporation, October 1981.
- 5.6 S&L Design Information Transmittal, DIT No. DIT-CR-0044, Subject: "Control Complex Volume", 10/1/97. (Attachment H)
- 5.7 FPC correspondence No. 3F0587-11 from E. C. Simpson to NRC, dated 5/7/87, Subject: "Control Room Habitability Sulfur Dioxide Supplement Report".
- 5.8 FPC correspondence No. 3F0687-16 from E. C. Simpson to NRC, dated 6/30/87, Subject: "Control Room Habitability Evaluation Report".
- 5.9 Gilbert/Commonwealth correspondence No. FCS-14429 from M. J. Cambria and R. W. Adler to FPC, dated 8/17/94, Subject: "Crystal River Unit 3 Control Room Habitability Toxic Gas Protection".
- 5.10 FPC correspondence No. 3F0588-10 from R. C. Widell to NRC, dated 5/23/88, Subject: "Control Room Habitability, Request for Additional Information".
- 5.11 Crystal River Unit 3 Updated Final Safety Analysis Report, Table 2-13, Rev. 0.
- 5.12 1993 ASHRAE Fundamentals Handbook, I-P Edition, Section 24.6, Table 1 "Climatic Conditions for the United States".
- 5.13 Drawings:
- 5.13a Black & Veatch Drawing No. A0001 Rev. 14
- 5.13b Zurn Industries, Inc. Drawing No. A-3 Rev. 2

- 5.13c Zurn Industries, Inc. Drawing No. A-2 Rev. 3  
5.13d Black & Veatch Drawing No. 14774-CSTU-S1033 Rev. 8  
5.13e Black & Veatch Drawing No. 14774-CSTU-S3002 Rev. 14  
5.13f FPC Drawing No. CR3-G85-D Rev. 3  
5.13g Black & Veatch Drawing No. M1058 Rev. 14  
5.13h Wahlco International, Inc. Drawing No. S-1-1 Rev. 2
- 5.14 "The Chlorine Manual", published by The Chlorine Institute, Fifth Edition, 1986.
- 5.15 Dangerous Properties of Industrial Materials, N. Irving Sax, Third Edition, 1968.
- 5.16 <sup>URC 05W 12/14/97</sup> U.S. Regulatory Guide 1.4, Rev. 2, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors", June 1974.
- 5.17 Meteorology and Atomic Energy - 1968, David H. Slade, Editor, 1968.
- 5.18 U.S. Environmental Protection Agency Report No. EPA-454/B-95-003b, "User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II - Description of Model Algorithms", September 1995.
- 5.19 FPC Calculation No. I-87-0005, Rev. 2.
- 5.20 Mark's Standard Handbook for Mechanical Engineers, E.A. Avallone, Editor, Ninth Edition, 1987.
- 5.21 Modern Compressible Flow with Historic Perspective, John D. Anderson, Jr., Second Edition, 1990.
- 5.22 Crane Technical Paper 410, "Flow of Fluids Through Valves, Fittings, and Pipe", Twenty Fifth Printing, 1991.
- 5.23 Chemical Engineers' Handbook, John H. Perry, Editor, 1950
- 5.24 Fundamentals of Pipe Flow, Robert P. Benedict, 1980.
- 5.25 Cermak Peterka Petersen, Inc. Report 97-1526.RO, issued to Sargent & Lundy, November 1997 (see Attachment F)
- 5.26 S&L Design Information Transmittal, DIT No. DIT-CR-0054-1, Subject: "Maximum unfiltered inleakage", 11/25/97. (Attachment H)

## 6.0 Calculations

### 6.1 Puff Diffusion

The liquid mass that initially flashes to vapor,  $Q$ , is given by the product of the flashing fraction,  $\chi_i$ , and the initial mass  $M$  (Ref. 5.2)

$$\chi_i = \frac{c_p(T_a - T_b)}{h_{fg}}$$

where

$c_p$  = chemical specific heat (J/kg-K)

$T_a$  = atmospheric temperature (K)

$T_b$  = chemical boiling temperature at one atmosphere (K)

$h_{fg}$  = chemical latent heat of vaporization (J/kg)

$$Q = \chi_i M \quad (\text{kg})$$

The puff dispersion coefficient that corresponds to the initial flashing mass is given by (Ref. 5.2)

$$\sigma_i = \left[ \frac{Q}{\sqrt{2\pi^3} \rho_v} \right]^{1/3}$$

where  $\rho_v$  = density of chemical vapor (kg/m<sup>3</sup>)

The Pasquill atmospheric stability class curves provide horizontal and vertical dispersion coefficients,  $\sigma_{hi}$  and  $\sigma_{vi}$  respectively, based on a point source without meander and building wake effects. These curves are shown in Attachment A. To facilitate numerical computation, curve fit approximations taken from Reference 5.18 are used in the model.

To account for the initial volume of the puff, these coefficients are modified per Reference 5.2 as shown below.

$$\sigma_h = \sqrt{\sigma_i^2 + \sigma_{hi}^2} \quad (\text{m})$$

$$\sigma_v = \sqrt{\sigma_i^2 + \sigma_{vi}^2} \quad (\text{m})$$

Consistent with an (x,y,z) coordinate nomenclature, the dispersion coefficients are written as:

$$\sigma_x = \sigma_h$$

$$\sigma_y = \sigma_x = \sigma_h$$

$$\sigma_z = \sigma_v$$

The Gaussian diffusion model for a puff results in the following equation for the concentration at the air intake (References 5.2 and 5.17)

$$\chi_{puff}(x, y, z, h) = \frac{Q}{(2\pi)^{1.5} \sigma_x \sigma_y \sigma_z} \exp\left\{-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right)\right\} \left\{\exp\left(\frac{-1(z-h)^2}{2\sigma_z^2}\right) + \exp\left(\frac{-1(z+h)^2}{2\sigma_z^2}\right)\right\} \text{ (kg/m}^3\text{)}$$

where:

$$x = x_o - Ut \quad (\text{m})$$

$$U = \text{wind speed (m/s)}$$

$$t = \text{time (s)}$$

Since the puff is assumed to travel in a straight line from the source to the control complex air intake, the center-line concentration is obtained by setting  $y = 0$ , per Reference 5.2.

The alternate diffusion model of Reference 5.3, which assumes a uniformly distributed vertical layer extending from grade elevation to the air intake, has the form shown below.

$$\chi(x, z) = \frac{Q}{2\pi \sigma_x \sigma_{y,z}} \exp\left\{-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}\right)\right\} \quad (\text{kg/m}^3)$$

The minimum puff concentration calculated using these two methods is used in the analysis.

## 6.2 Plume Diffusion

After the initial flashing of liquid to vapor, the remaining mass will spill onto the ground and begin to evaporate, resulting in a continuous chemical plume release. The diffusion equation for a continuous plume release with a finite initial volume is given by Reference 5.2 as the following:

$$\chi_{plume}(x, y, z, h) = \frac{\dot{Q}}{2\pi U \sigma_y \sigma_z} \exp\left\{-\frac{1}{2}\left(\frac{y^2}{\sigma_y^2}\right)\right\} \left\{\exp\left(\frac{-1(z-h)^2}{2\sigma_z^2}\right) + \exp\left(\frac{-1(z+h)^2}{2\sigma_z^2}\right)\right\} \quad (\text{kg/m}^3)$$

where:

$$\dot{Q} = \text{continuous source strength (kg/s)}$$

As in the case of the Gaussian puff model,  $y$  is set to zero to calculate the center-line concentration. In addition, for heavier than air gases the values of  $z$  and  $h$  are set to zero, per Reference 5.2.

### 6.2.1 Evaporation Rate

The continuous source strength is determined by calculating the evaporation rate of the liquid spill due to various heat transfer mechanisms, per Ref. 5.2.

The heat flux due to atmospheric and solar radiation is given as (Ref. 5.2):

$$q_r = 275 \text{ (cal/m}^2\text{-sec)}$$

The heat flux due to forced convection of air over the spill is given as (Ref. 5.2):

$$q_c = 1.6 \left( \frac{U}{1.0} \right)^{0.6} (T_a - T_b) \text{ (cal/m}^2\text{-sec)}$$

The heat transfer coefficient of 1.6 cal/m<sup>2</sup>-sec-°C at 1.0 m/sec, as documented in Ref. 5.2, is adjusted for other values of wind speed by the term  $(U/1.0)^{0.6}$ .

The heat flux due to conduction from the earth is given as (Ref. 5.2):

$$q_d = 197 \frac{(T_e - T_b)}{t^{1/2}} \text{ (cal/m}^2\text{-sec)}$$

This is based on the following assumed properties for the earth:

thermal conductivity of  $4.0 \times 10^{-3}$  (cal/cm-sec-°C)

density of 1.52 (gm/cm<sup>3</sup>)

specific heat of 0.2 (cal/gm-°C)

The evaporation rate is calculated using the total heat flux, the spill area and the latent heat of vaporization as shown below (Ref. 5.2).

$$\dot{Q} = \frac{A(t)}{h_{fg}} (4.186 \text{ J/cal}) [q_r + q_c + q_d] \text{ (kg/s)}$$

As the liquid spreads out, the surface area will increase according to the equation given below (Ref. 5.2):

$$A = \pi \left\{ r_o^2 + 2t \left[ \frac{gV_o(\rho_l - \rho_a)}{\pi\rho_l} \right]^{1/2} \right\}$$

where:

$V_o$  = volume of remaining liquid spill (m<sup>3</sup>)

$$r_o = \left[ \frac{V_o}{\pi} \right]^{1/3} \quad (\text{m})$$

$\rho_l$  = density of chemical liquid ( $\text{kg/m}^3$ )

$\rho_a$  = density of air ( $\text{kg/m}^3$ )

The expression for the liquid spill surface area is based on the assumption that the initial shape of the liquid body is a cylinder, with the height equal to the base. The liquid spreads quickly by gravity into a thin layer. This equation neglects the effects of surface tension and viscosity, but is regarded by Reference 5.2 as an acceptable first approximation to the spill area.

The surface area is limited to a maximum value corresponding to the initial volume at a thickness of 1 cm, per Reference 5.2.

As the spill volume is depleted due to evaporation, the area will begin to decrease its maximum computed value.

## 6.2.2 Piping or Valve Leakage Rate

### 6.2.2.1 Chlorine at CR Units 4/5

For the chlorine release accident scenario at CR Units 4/5, a single one-ton tank is assumed to fail instantaneously. This tank is aligned to a common piping header which also serves three other one-ton chlorine tanks. The contents of the three intact containers are assumed to escape to the atmosphere through the failed container, via the connecting conduit. This leakage rate is calculated based on the assumption of critical isentropic flow, limited by the cross-sectional area of the 3/8 inch copper tubing connections.

The critical mass flow rate is given by the equation below:

$$\dot{m} = \rho^* a^* A \quad (\text{kg/sec})$$

where:

$\rho^*$  = gas density at sonic conditions ( $\text{kg/m}^3$ )

$a^*$  = gas sonic velocity (m/sec)

$A$  = flow area of pipe or valve ( $\text{m}^2$ )

Reference 5.21 provides the following equations for determining thermodynamic properties at sonic conditions (superscript \*) based on stagnation conditions (subscript o).

$$\rho^* = \rho_o \left[ \frac{2}{\gamma + 1} \right]^{\frac{1}{\gamma - 1}}$$

$$T^* = T_o \frac{2}{\gamma + 1}$$

$$a^* = \sqrt{\gamma R T^*}$$

where:

$\gamma$  = polytropic gas constant (obtained from Reference 5.22)

$\rho_o$  = gas density at stagnation conditions (kg/m<sup>3</sup>)

$T_o$  = gas temperature at stagnation conditions (K)

$T^*$  = gas temperature at sonic conditions (K)

R = gas constant (J/kg-K)

It is assumed that the stagnation density is equal to the density of saturated vapor at the limiting chemical tank temperature of 90 °F. This is consistent with the assumption that the chemical will flash from liquid to vapor as it escapes from the tank, through the piping and/or valving arrangement. With the chlorine tanks assumed to be in the upright position, the liquid/vapor interface will remain below the outlet, providing saturated vapor to the tank outlet.

$$\rho_o = \rho_v = \frac{P_v}{RT_o}$$

For Cl<sub>2</sub> at CR Units 4/5, the limiting flow area is 8.188 x 10<sup>-5</sup> m<sup>2</sup> corresponding to 3/8" copper tubing, per Assumption 3.9 and Design Input 4.1.6.

<u>Parameter</u>	<u>Value for Chlorine</u>
P <sub>v</sub> at 90 °F (psia)	137.7
$\gamma$	1.33
R (J/kg-K)	117.26
$\rho_v$ (kg/m <sup>3</sup> )	26.49
$\rho^*$ (kg/m <sup>3</sup> )	16.67
T <sub>o</sub> (K)	305.6
T <sup>*</sup> (K)	262.3
a <sup>*</sup> (m/sec)	202.3
A (m <sup>2</sup> )	8.188 x 10 <sup>-5</sup>
$\dot{m}$ (kg/sec)	0.276

For the  $\text{Cl}_2$  release at CR Units 4/5, the leak rate listed above will be multiplied by three, since a maximum of three chlorine containers can contribute to the vapor plume via leakage through the failed container. Therefore, following the initial rupture of a single  $\text{Cl}_2$  tank, the total  $\text{Cl}_2$  leak rate from the remaining three tanks which are headered together at CR Units 4/5 is 0.828 kg/sec.

#### 6.2.2.2 Sulfur Dioxide at CR Units 1/2

Reference 5.1 suggests that the consequences of a 'maximum concentration-duration accident' be examined. This corresponds to a continuous chemical release due to a valve or piping leak. The failure of a valve at the CR Units 1/2  $\text{SO}_2$  tank is judged to be the limiting scenario for  $\text{SO}_2$ , due to the close proximity of the tank to the CR Unit 3 air intake. For chlorine, the valve leakage scenario is bounded by the analysis of  $\text{Cl}_2$  at CR Units 4/5 described in Section 6.2.2.1, as the  $\text{Cl}_2$  piping connections are expected to be the same at the Helper Cooling Towers, and the leak rate is independent of tank size or internal pressure.

For the  $\text{SO}_2$  tank at CR Units 1/2, the limiting continuous release is judged to be the failure of the 2-inch fill line located below the centerline of the tank, as shown in Reference 5.13h. Under these conditions, the leak rate is calculated based on a liquid discharge at the critical flow rate, per the methodology of Reference 5.24. The maximum flow rate occurs when the exit pressure of the leak equals the saturation pressure corresponding to the fluid temperature. Under this condition, liquid flow will persist throughout the failed piping/valving, no matter how low the back pressure is. After exiting the break, the fluid will partially flash to vapor due to the low backpressure at ambient conditions. The mass that is calculated to flash is added directly to the puff, while the remaining liquid is discharged to the ground where it evaporates, contributing to the vapor plume.

Equation 9.2 of Reference 5.24 provides the basis for calculating the maximum leak rate per unit area for flows with a backpressure that is less than the fluid saturation pressure:

$$G_o = \left[ \frac{144 \alpha g_e}{\frac{d\beta}{dP} + v_f \left( \frac{d\alpha}{dP} - \frac{144}{J} \right)} \right]^{1/2}_{P_i}$$

with:  $\alpha = h_g / v_{fg}$   
 $\beta = h_f - \alpha v_f$

where:

$G_o$  = Mass flux [ $\text{lb}_m/\text{ft}^2\text{-sec}$ ]  
 $h_f$  = enthalpy of saturated liquid [ $\text{Btu}/\text{lb}_m$ ]  
 $h_g$  = enthalpy of saturated vapor [ $\text{Btu}/\text{lb}_m$ ]  
 $h_{fg}$  = latent heat of vaporization =  $h_g - h_f$  [ $\text{Btu}/\text{lb}_m$ ]  
 $v_f$  = specific volume of saturated liquid [ $\text{ft}^3/\text{lb}_m$ ]  
 $v_g$  = specific volume of saturated vapor [ $\text{ft}^3/\text{lb}_m$ ]



$$v_{fg} = v_g - v_f \text{ [ft}^3/\text{lb}_m\text{]}$$

$$J = \text{mechanical equivalent of heat} = 778.16 \text{ ft-lb}_f/\text{Btu}$$

$$g_c = \text{conversion factor} = 32.2 \text{ lb}_m\text{-ft/lb}_f\text{-sec}^2$$

$$P_s = \text{saturation pressure at fluid temperature [psia]}$$

This equation is used to calculate the critical flow of liquid  $\text{SO}_2$  at the saturation pressure of 71 psia, corresponding to the assumed ambient temperature of 90 °F. This calculation is shown in Table 5, and it results in a maximum mass flux of 1453.1  $\text{lb}_m/\text{ft}^2\text{-sec}$ . Thermodynamic property data for  $\text{SO}_2$  are taken from Reference 5.23.

For  $\text{SO}_2$  at CR Units 1/2, the maximum flow area is associated with the 2-inch fill connection, as shown in Reference 5.13h. For 2-inch Schedule 40 piping (Assumption 3.13), the flow area is 0.0233  $\text{ft}^2$  (0.00216  $\text{m}^2$ ), per Reference 5.22. Multiplying the flow area by the calculated mass flux results in a maximum leakage rate of 33.86  $\text{lb}_m/\text{sec}$  (15.36  $\text{kg/sec}$ ). Of this flow rate, a fraction flashes instantaneously to vapor, while the remainder contributes to the liquid pool available for evaporation. The flashing fraction,  $\chi_i$ , is calculated per the equation presented in Section 6.1, and it has a value of 0.165 for  $\text{SO}_2$  at 90 °F. Therefore, the mass flow rate of vapor going directly to the plume is 2.53  $\text{kg/sec}$ , and the remaining 12.83  $\text{kg/sec}$  contributes to the liquid pool.

### 6.3. Plume Meander and Wake Effects

As cited in Reference 5.5, the effluent concentrations measured at low wind speeds are usually substantially lower than those predicted using the Pasquill dispersion coefficients. The reduced concentrations are due primarily to enhanced horizontal spreading of the plume as it meanders over a large area. This meandering produces  $\sigma_{hi}$  values that are much larger than those obtained by the Pasquill curves. To account for this effect, use is made of a meander factor,  $M_f$ , which modifies the value of  $\sigma_{hi}$  to include the lateral plume spread due to meander,  $\Sigma_y$ . The value of  $\Sigma_y$  is calculated as (Ref. 5.4)

$$\Sigma_y = M_f \sigma_{hi} \quad \text{for distances less than or equal to 800 meters}$$

$$\Sigma_y = (M_f - 1) \sigma_{hi800m} + \sigma_{hi} \quad \text{for distances greater than 800 meters}$$

The meander factor is a function of wind speed and atmospheric stability class, and is shown in Attachment A. The value of  $M_f$  is a constant for wind speeds less than 2 m/sec, and decreases to a minimum value of 1 at a wind speed of 6 m/sec. To facilitate numerical computation, the variable portion of the  $M_f$  curve is expressed by an equation of the form:

$$M_f = CU^\alpha$$

where  $C$  and  $\alpha$  are constants, and have the values listed below:

Atmospheric Stability Class

C

$\alpha$

Type D	3.097	-0.631
Type E	6.00	-1.0
Type F	9.592	-1.262
Type G	18.583	-1.631

The building wake factor, WF, has a permissible range of 1 to 3 per References 5.5 and 5.16, and directly reduces the calculated concentration as it appears in the denominator per Ref. 5.5. To credit both meander and wake effects, the plume concentration is computed using the minimum value calculated from the two equations shown below. The exponential terms are not shown, but are implied, using consistent values of  $\sigma_y$  and  $\Sigma_y$  respectively.

$$\frac{\chi}{Q} = \frac{1}{U\pi\sigma_y\sigma_z WF}$$

$$\frac{\chi}{Q} = \frac{1}{U\pi\Sigma_y\sigma_z}$$

#### 6.4 Concentration at the Control Complex Air Intake

Per Reference 5.2, the concentration at the air intake at any time,  $C_o(t)$ , is obtained by summing the contributions due to the initial vapor puff, and the continuous plume due to evaporation.

#### 6.5 Control Complex Concentration

Once the concentration at the air intake is known, the control complex concentration can be determined using the equation below (Ref. 5.2).

$$C_r(t_j) = C_r(t_{j-1}) + [C_o(t_j) - C_r(t_{j-1})](1 - \exp^{-W\Delta t/V})$$

where:

$C_r(t_j)$  = Control complex concentration at the  $j^{\text{th}}$  timestep (ppm)

$C_o(t_j)$  = Air intake concentration at the  $j^{\text{th}}$  timestep (ppm)

$W$  = the ventilation/infiltration rate before/after isolation (cfm/(60sec/min))

$\Delta t$  = timestep (s)

$V$  = control complex volume ( $\text{ft}^3$ )

This approximation to the exact analytical solution is valid for small timestep values. Larger timesteps generally lead to higher calculated values of control complex concentrations, and reduces accuracy. This calculation employs a timestep of 1 second, which provides good accuracy and relatively quick computer runtimes.

The computer code parametrically searches through a range of wind speeds to find the wind speed that results in the highest control complex concentration two minutes after detection, per the direction of Reference 5.1. The wind speed range used in this analysis is 1.0 to 6.0 m/sec, with an increment of 0.1 m/sec. The lower bound of 1.0 m/sec corresponds to a wind speed of 2.24 mph, which is approximately one-half the average wind speed of 4.4 mph associated with atmospheric stability class F during the month of July, per Reference 5.11. This is a conservative lower bound, as calculated control room concentrations generally increase at lower wind speeds. The lower bound of 1.0 m/sec is also consistent with the lower bound wind speed associated with meander effects cited in Reference 5.5.

The upper bound of 6.0 m/sec is an appropriate value for atmospheric stability class F, per the discussion on page 52 of Reference 5.3. This reference states that with wind speeds greater than 5 m/sec, the Pasquill stability criterion will rarely be more stable than Type E.



## 7.0 Results/Conclusions

### 7.1 Maximum Allowable Chemical Amounts without Automatic Isolation

In order to determine the maximum amount of chlorine and sulfur dioxide that can be stored onsite without control complex isolation, Crystal River Unit 3 control complex concentrations are calculated based on nasal detection of the release by control room personnel. Acceptable chemical amounts correspond to control complex concentrations which are less than the toxicity limit at two minutes after nasal detection, without automatic isolation. The toxicity limits are 15 ppm for  $\text{Cl}_2$  and 36 ppm for  $\text{SO}_2$ .

Tables 1 through 4 list the parametric results for the maximum chemical amounts without automatic isolation. For chlorine at the Helper Cooling Towers, Table 1 shows that the maximum permissible amount is approximately 3.0 tons.

For chlorine at CR Units 4/5, a maximum of four one-ton containers are connected to a common header, per Design Input 4.2.2. Failure of one container is modeled as the immediate release of one ton of  $\text{Cl}_2$ , with the remaining three tons available to contribute to the release at a constant rate of 0.828 kg/sec until depleted. This is the most likely failure mode, as angle valves separate each container aligned to the header, per Reference 5.13g. The simultaneous failure of two or more containers is unlikely, and will not be analyzed in this calculation. Table 2 shows the results of an instantaneous single container failure, with leakage contribution from the remaining three. This postulated failure mechanism results in a control complex concentration of 7.48 ppm, below the toxicity limit.

Table 3 shows that the maximum amount of sulfur dioxide permissible at the Helper Cooling Towers (HCT's) is 17.3 tons without automatic isolation. This is based on a nasal detection concentration of 3.0 ppm. The one ton  $\text{SO}_2$  containers at CR Units 4/5 are not analyzed, as the consequences of a postulated failure are bounded by the failure at the Helper Cooling Towers. The amount of  $\text{SO}_2$  at CR Units 4/5 is less than at the HCT's, farther away from the CR Unit 3 air intake (3600 feet versus 3400 ft) and has a larger building wake factor (3 versus 2 at the HCT's). The combined effect of these factors will result in lower calculated  $\text{SO}_2$  concentrations in the control complex than those documented for the HCT release.

For sulfur dioxide at CR Units 1/2, Table 4 shows that 1.4 tons is the maximum permissible amount, without automatic control complex isolation. This is due to the close proximity (750 feet) of the source to the air intake. This includes the maximum allowable wake factor of 3.0, and it also includes the berm which limits the spill surface area to 55.75  $\text{m}^2$ . It is recommended that measures be taken to mitigate the effects of a failure of this tank. These include, but are not limited to, reducing administrative limits on the amount of  $\text{SO}_2$  stored at this tank, enclosing the tank in a structure, or employing an alternative choice of chemical for use at this location if automatic detection/isolation mechanisms are not employed.



## 7.2 Maximum Response Time of Automatic Detection/Isolation Systems

For chemical amounts in excess of the limiting values listed in Tables 1 through 4, automatic detection and control complex isolation are required. The total isolation response time includes any possible delay times associated with the sensor at the air intake, plus the closing time of the control complex isolation dampers. In order to determine the maximum allowable response time to achieve control complex isolation following sensor detection at the air intake, limiting scenarios are examined for both chlorine and sulfur dioxide onsite releases. The ventilation/infiltration rates into the control complex before/after isolation are 5700 cfm and 435 cfm respectively. For chlorine, the limiting scenario is a failure of the 17 ton tank at the Helper Cooling Tower. For a detection level of 5 ppm, the maximum response time is approximately 29 seconds, based on the results shown below.

17 ton Chlorine Tank at the Helper Cooling Towers	
<u>Response Time (sec)</u>	<u>Control Complex Concentration (ppm)</u>
25	12.54
29	15.15

For a failure of the 50 ton SO<sub>2</sub> tank at the Helper Cooling Towers, the maximum allowable isolation response time is determined based on a detection level of 2.4 ppm. The maximum isolation delay time is approximately 33 seconds, based on the results shown below.

50 ton Sulfur Dioxide Tank at the Helper Cooling Towers	
<u>Response Time (sec)</u>	<u>Control Complex Concentration (ppm)</u>
30	31.84
33	35.21

In the case of sulfur dioxide at CR Units 1/2, the current administrative limit is 30 tons based on the evaluations provided in Reference 5.19, assuming automatic isolation with a 30 second response time. It should be noted that the analysis of Reference 5.19 employs Pasquill stability class Type B as the limiting atmospheric stability class. In addition, the results documented in Reference 5.19 are based on a air intake height of 26.5 meters, without implementing the methodology of setting  $z = 0$ , per the guidance of References 5.2 and 5.3.

This calculation will determine an upper bound volume (mass) limit of SO<sub>2</sub> at CR Units 1/2, assuming a 30 second response time, consistent with the current analyzed response time provided in Reference 5.7. In order to remain below the two-minute toxicity limit following a failure of the tank, the maximum allowable amount of SO<sub>2</sub> at CR Units 1/2 is 4.5 tons.

Maximum Sulfur Dioxide Amounts at Crystal River Units 1/2		
<u>Response Time (sec)</u>	<u>SO<sub>2</sub> mass (tons)</u>	<u>Control Complex Concentration (ppm)</u>
30	4.5	35.88

For the continuous valve leakage case, the calculated control complex concentration two minutes after automatic detection is 22.37 ppm. Therefore, the instantaneous failure of the SO<sub>2</sub> tank at CR Units 1/2 is the limiting accident scenario.

### 7.3 Incorporation of Wind Tunnel Testing Data

The methods employed in this calculation for computing control complex chemical concentrations are based on the methodologies of References 5.1, 5.2, 5.3, 5.4, and 5.5. It is recognized that these methodologies provide a conservative estimate of the actual transport mechanisms and the control complex chemical concentration. This is primarily due to the conservative recommendation cited in Reference 5.2 that the control complex air intake be modeled as being at the ground level. Another conservatism is the upper limit of three on the allowable building wake factor. The dilution of the chemical puff/plume due to site-specific geometry effects is very difficult to quantify analytically, but is expected to be much greater than that allowed by the regulatory guidance cited above.

To understand the degree of conservatism implicit in the analysis of this calculation, wind tunnel testing/modeling was conducted by Cermak Peterka Petersen, Inc. (CPP). Specifically, CPP modeled the actual building geometry of Crystal River Units 1, 2, and 3. The modeled scenario is representative of the SO<sub>2</sub> tank failure at CR Units 1/2, releasing 30 tons of SO<sub>2</sub>, with the chemical release being swept towards the CR Unit 3 control complex air intake under stable atmospheric conditions. The wind tunnel model included the instantaneous puff release corresponding to the initial flashing fraction of 0.165 for SO<sub>2</sub> at 90 °F. The continuous plume release associated with the liquid evaporation rate was also modeled. Chemical concentrations were measured at the location of the CR Unit 3 control complex air intake location to provide a time history of the release. Results from these tests are included in Attachment F. From this data of time-dependent chemical concentrations at the air intake location, the control complex concentration is calculated utilizing the equation shown in Section 6.5 of this calculation assuming no isolation of the control complex. This analysis is shown in Table 6, and results in a computed control complex concentration of 24.93 ppm two minutes after nasal detection. Plots of the CPP test measurements of air intake concentration are shown in Figures 1 through Figure 3. The calculation of control complex concentrations derived from the CPP air intake data is shown in Figure 4.

In order to compare the CPP data to the analytical methodology, a computer code case was run using the same parameters as those modeled in the CPP wind tunnel experiments. That is, a 30 ton instantaneous SO<sub>2</sub> release at CR Units 1/2, with no automatic isolation of the CR Unit 3 control complex. For this case, the analytical model predicts a control complex concentration of 277 ppm two minutes after nasal detection, with no isolation of the control complex. The table below lists a comparison of the important parameters between the CPP wind tunnel model results and the analytical results obtained from the computer code developed in this calculation.

<u>Parameter</u>	<u>CPP Wind Tunnel Model</u>	<u>Analytical Results</u>	<u>Ratio</u>
Peak Puff Concentration at Air Intake	903 ppm	24060 ppm	26.6
Peak Plume Concentration at Air Intake	52 ppm	2330 ppm	44.8
Peak Air Intake Concentration	906 ppm	26373 ppm	29.1
Control Complex Concentration Two Minutes after Detection	24.93 ppm*	277 ppm	11.1

\* Concentration derived from air intake concentration using the equation presented in Section 6.5

The comparison shown above illustrates the conservatisms inherent in the analytical methodologies provided in References 5.1 through 5.5. When compared to the CPP wind tunnel modeling, the discrepancy in CR Unit 3 control complex chemical concentration, for the specific case of a 30 ton SO<sub>2</sub> release at CR Units 1/2, is approximately a factor of 11. Based on this comparison, it is judged that a factor of three can safely be applied to the values listed in Tables 1, 3, and 4 for quantifying the maximum amount of chemical that can be stored at each respective location, with the calculated control complex concentration remaining below the two minute toxicity limit without the use of automatic detection and isolation systems.

Specifically, for chlorine at the Helper Cooling Towers, Table 1 shows that the maximum allowable amount is three tons without the use of automatic detection/isolation. For three times this amount, or nine tons, the analytical model predicts a control complex concentration of 32.26 ppm, or 2.15 times the toxicity limit of 15 ppm. For sulfur dioxide at the Helper Cooling Towers, Table 3 shows that the maximum allowable amount is 17.3 tons without the use of automatic detection/isolation. For three times this amount, or approximately 50 tons, the analytical model predicts a control complex concentration of 77.16 ppm, or 2.14 times the toxicity limit of 36 ppm. Based on the factor of 11 shown above, it is judged that the storage of nine tons of chlorine and 50 tons of sulfur dioxide at the Helper Cooling Towers is acceptable without automatic detection/isolation capability.

For sulfur dioxide at CR Units 1/2, the wind tunnel testing data can be applied directly. Table 6 shows that the nasal detection concentration of 3 ppm is reached at 51.0 seconds. With no isolation of the control complex, the calculated concentration two minutes after nasal detection is 24.93 ppm, well below the toxicity limit of 36 ppm. Therefore, the CPP wind tunnel data show that no isolation is required for a 30 ton SO<sub>2</sub> release at CR Units 1/2.

**Table 1**  
**Chlorine Release at the Helper Cooling Tower without Automatic Isolation**

Chemical Location	Cl <sub>2</sub> HCT	CR concentration at two minutes after nasal detection	
Parameter	Value	Spill size (lb)	(ppm)
Molecular Wt.	70.9	18,000 6,000	32.26 14.58
Nominal Tank size (lb)	34000		
Ambient Temperature (°F)	90		
Boiling Temperature (°F)	-29.4		
Distance from source to intake (ft)	3400		
Height of intake, z (ft)	86.83		
Control room volume (ft <sup>3</sup> )	364,922		
CR Infiltration before isolation (cfm)	5700		
Detection concentration (ppm)	3.5		
CR Infiltration after isolation (cfm)	435		
Toxicity limit (ppm)	15		
Wake Factor	2.0		
Stability Class	F		
Wind Speed; min, max (m/sec)	1.0, 6.0		
Wind Speed increment (m/sec)	0.1		
Time interval after detection for CR concentration, (sec)	120		
Time increment (sec)	1		



**Table 2**  
**Chlorine Release at CR Units 4 and 5 without Automatic Isolation**

Chemical Location	Cl <sub>2</sub> CR 4&5	CR concentration at two minutes after nasal	
Parameter	Value	Spill size (lb)	detection (ppm)
Molecular Wt.	70.9	2,000	7.48
Nominal Tank size (lb)	2000		
Ambient Temperature (°F)	90		
Boiling Temperature (°F)	-29.4		
Distance from source to intake (ft)	3600		
Height of intake, z (ft)	86.83		
Control room volume (ft <sup>3</sup> )	364,922		
CR Infiltration before isolation (cfm)	5700		
Detection concentration (ppm)	3.5		
CR Infiltration after isolation (cfm)	435		
Toxicity limit (ppm)	15		
Wake Factor	3.0		
Stability Class	F		
Wind Speed; min, max (m/sec)	1.0, 6.0		
Wind Speed increment (m/sec)	0.1		
Time interval after detection for CR concentration, (sec)	120		
Time increment (sec)	1		
Vapor release rate from other tanks on common header (kg/sec)	0.828		

**Table 3**  
**Sulfur Dioxide Release at the Helper Cooling Tower without Automatic Isolation**

Chemical Location	SO <sub>2</sub> HCT	CR concentration at two minutes after nasal detection	
Parameter	Value	Spill size (lb)	
Molecular Wt.	64.1		
Nominal Tank size (lb)	100000		
Ambient Temperature (°F)	90		
Boiling Temperature (°F)	14		
Distance from source to intake (ft)	3400		
Height of intake, z (ft)	86.83	100,000	77.16
Control room volume (ft <sup>3</sup> )	364,922	34,600	35.99
CR Infiltration before isolation (cfm)	5700		
Detection concentration (ppm)	3.0		
CR Infiltration after isolation (cfm)	435		
Toxicity limit (ppm)	36		
Wake Factor	2.0		
Stability Class	F		
Wind Speed; min, max (m/sec)	1.0, 6.0		
Wind Speed increment (m/sec)	0.1		
Time interval after detection for CR concentration, (sec)	120		
Time increment (sec)	1		

**Table 4**  
**Sulfur Dioxide Release at CR Units 1 and 2 without Automatic Isolation**

Chemical	SO <sub>2</sub>	CR concentration at two minutes after nasal detection	
Location	CR 1&2 Precipitator		
Parameter	Value	Spill size (lb)	(ppm)
Molecular Wt.	64.1	2,800	35.71
Nominal Tank size (lb)	90000		
Ambient Temperature (°F)	90		
Boiling Temperature (°F)	14		
Distance from source to intake (ft)	750		
Height of intake, z (ft)	86.83		
Control room volume (ft <sup>3</sup> )	364,922		
CR Infiltration before isolation (cfm)	5700		
Detection concentration (ppm)	3.0		
CR Infiltration after isolation (cfm)	435		
Toxicity limit (ppm)	36		
Wake Factor	3.0		
Stability Class	F		
Wind Speed; min, max (m/sec)	1.0, 6.0		
Wind Speed increment (m/sec)	0.1		
Time interval after detection for CR concentration, (sec)	120		
Time increment (sec)	1		

**Table 5**  
**Maximum Flashing Flow for Sulfur Dioxide**

T (°F)	P <sub>sat</sub> (psia)	h <sub>f</sub> (Btu/lb)	h <sub>g</sub> (Btu/lb)	h <sub>fg</sub> (Btu/lb)	v <sub>f</sub> (ft <sup>3</sup> /lb)	v <sub>g</sub> (ft <sup>3</sup> /lb)	v <sub>fg</sub> (ft <sup>3</sup> /lb)	α (Btu/ft <sup>3</sup> )	β (Btu/lb)	dβ/dP (Btu/lb-psia)	dα/dP (Btu/ft <sup>3</sup> -psia)	G <sub>o</sub> (lb/ft <sup>2</sup> -sec)
10	13.3	35.7	204	168.3	0.01092	5.77	5.759	29.223	35.381			
20	16.9	39	205.3	166.3	0.01103	4.59	4.579	36.318	38.599	0.894	1.971	429.30
30	21.3	42.2	206.4	164.2	0.01114	3.7	3.689	44.512	41.704	0.706	1.862	533.81
40	26.6	45.5	207.7	162.2	0.01125	3.02	3.009	53.909	44.894	0.602	1.773	635.15
50	32.9	48.7	208.7	160	0.01137	2.48	2.469	64.813	47.963	0.487	1.731	771.58
60	40.3	52	209.8	157.8	0.01149	2.05	2.039	77.409	51.111	0.425	1.702	900.36
70	49.1	55.3	210.8	155.5	0.01162	1.7	1.688	92.100	54.230	0.354	1.669	1071.86
80	59.3	58.6	211.7	153.1	0.01175	1.42	1.408	108.716	57.323	0.303	1.629	1254.76
90	71	61.9	212.6	150.7	0.01189	1.2	1.188	126.840	60.392	0.262	1.549	1453.07
100	84.1	65.3	213.5	148.2	0.01204	1.02	1.008	147.030	63.530	0.240	1.541	1632.33
110	99.1	68.8	214.5	145.7	0.01219	0.868	0.856	170.248	66.725	0.213	1.548	1854.20
120	116.3	72.2	215.2	143	0.01235	0.746	0.734	194.916	69.793	0.178	1.434	2159.48
130	135.8	75.8	215.8	140	0.01251	0.646	0.633	220.998	73.035	0.166	1.338	2381.35
140	157.7	79.3	216.4	137.1	0.01269	0.554	0.541	253.274	76.086	0.139	1.474	2746.80

**Table 6**  
**Analysis of CPP Wind Tunnel Test Data for 30 ton Sulfur Dioxide Release at CR Units 1/2**

Control Complex Volume (ft<sup>3</sup>)                      364922  
Ventilation Rate (cfm)                              5700  
Nasal Detection Concentration (ppm)              3

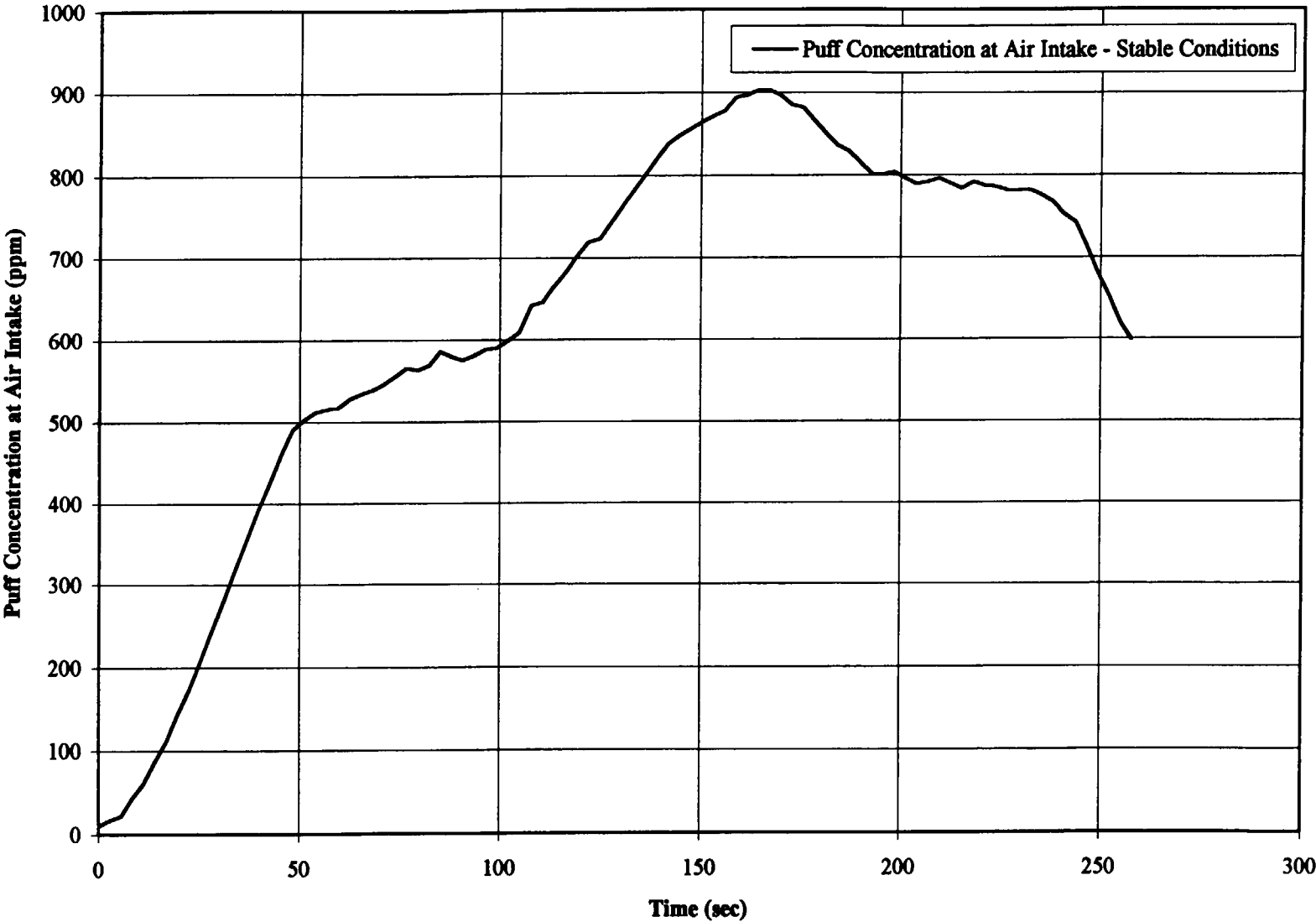
time (sec)	Puff Concentration (ppm)	Plume Concentration (ppm)	Total Intake Concentration Co (ppm)	Control Complex Concentration Cr (ppm)
0.0	10.0	4.0	14.0	0
2.8	17.0	2.0	19.0	0.01
5.7	22.0	5.0	27.0	0.03
8.5	43.0	4.0	47.0	0.07
11.3	61.0	2.0	63.0	0.11
14.2	87.0	1.0	88.0	0.18
17.0	111.0	2.0	113.0	0.26
19.8	143.0	2.0	145.0	0.37
22.7	175.0	4.0	179.0	0.50
25.5	210.0	3.0	213.0	0.66
28.3	246.0	5.0	251.0	0.84
31.2	281.0	1.0	282.0	1.05
34.0	319.0	2.0	321.0	1.29
36.8	354.0	1.0	355.0	1.54
39.7	392.0	3.0	395.0	1.84
42.5	425.0	2.0	427.0	2.15
45.3	459.0	4.0	463.0	2.49
48.2	490.0	1.0	491.0	2.85
51.0	502.0	2.0	504.0	3.22
53.8	511.0	2.0	513.0	3.59
56.7	515.0	1.0	516.0	3.98
59.5	517.0	3.0	520.0	4.35
62.3	528.0	4.0	532.0	4.74
65.2	534.0	5.0	539.0	5.14
68.0	539.0	2.0	541.0	5.53
70.8	546.0	1.0	547.0	5.93
73.7	556.0	2.0	558.0	6.34
76.5	566.0	3.0	569.0	6.75
79.3	563.0	1.0	564.0	7.16
82.2	569.0	4.0	573.0	7.59
85.0	586.0	3.0	589.0	8.01
87.8	580.0	2.0	582.0	8.43
90.7	575.0	1.0	576.0	8.86
93.5	581.0	2.0	583.0	9.27
96.3	588.0	4.0	592.0	9.70
99.2	590.0	3.0	593.0	10.14
102.0	599.0	4.0	603.0	10.57
104.8	609.0	2.0	611.0	11.01
107.7	642.0	1.0	643.0	11.49
110.5	646.0	2.0	648.0	11.95
113.3	665.0	3.0	668.0	12.43
116.2	682.0	1.0	683.0	12.93
119.0	702.0	4.0	706.0	13.44

**Table 6**

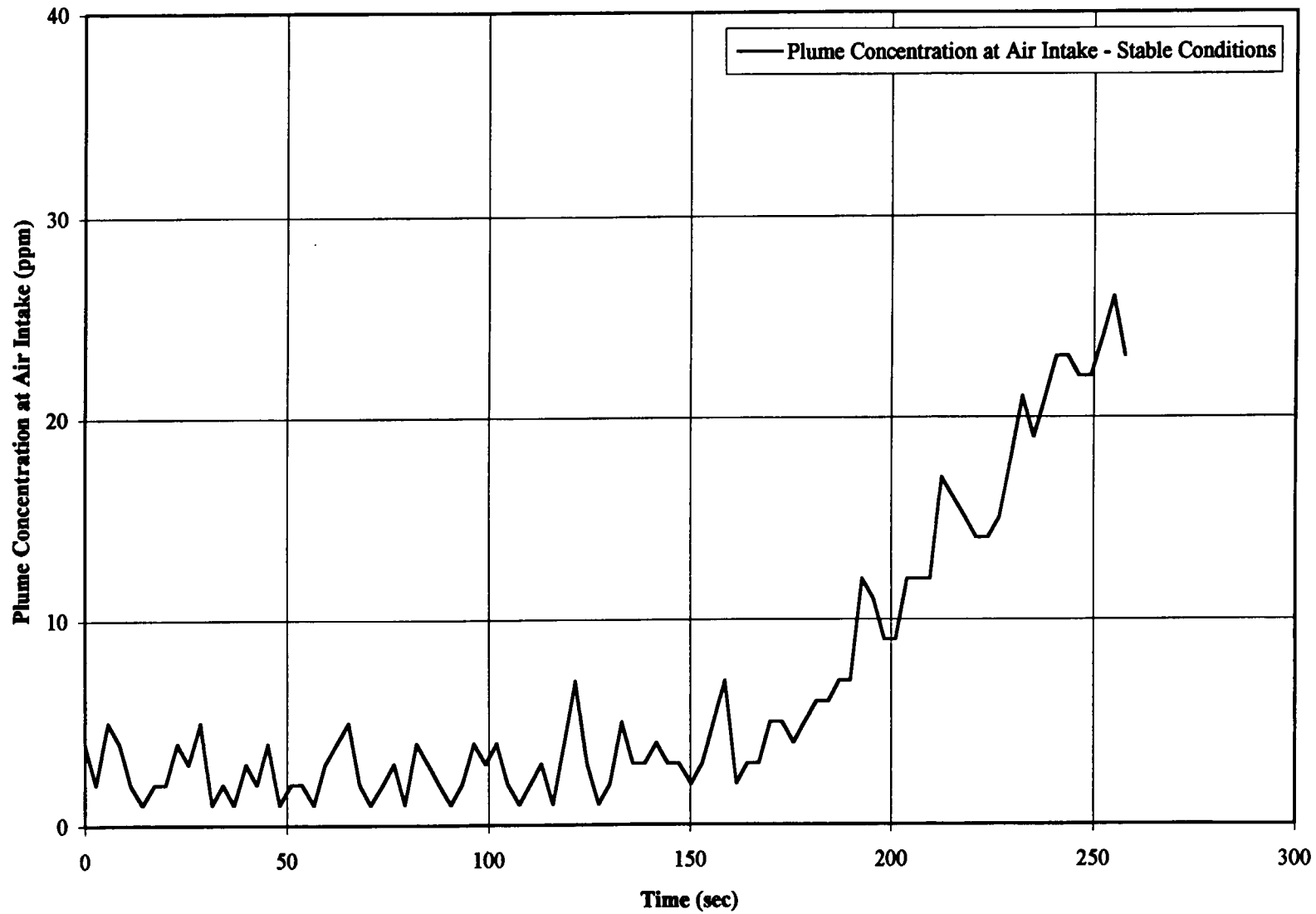
**Analysis of CPP Wind Tunnel Test Data for 30 ton Sulfur Dioxide Release at CR Units 1/2**

121.8	719.0	7.0	726.0	13.96
124.7	724.0	3.0	727.0	14.50
127.5	743.0	1.0	744.0	15.03
130.3	762.0	2.0	764.0	15.57
133.2	781.0	5.0	786.0	16.16
136.0	800.0	3.0	803.0	16.73
138.8	819.0	3.0	822.0	17.32
141.7	838.0	4.0	842.0	17.94
144.5	848.0	3.0	851.0	18.54
147.3	856.0	3.0	859.0	19.16
150.2	864.0	2.0	866.0	19.80
153.0	872.0	3.0	875.0	20.42
155.8	878.0	5.0	883.0	21.05
158.7	894.0	7.0	901.0	21.71
161.5	897.0	2.0	899.0	22.35
164.3	903.0	3.0	906.0	22.99
167.2	903.0	3.0	906.0	23.66
170.0	897.0	5.0	902.0	24.30
172.8	885.0	5.0	890.0	24.93
175.7	882.0	4.0	886.0	25.58
178.5	866.0	5.0	871.0	26.20
181.3	851.0	6.0	857.0	26.80
184.2	836.0	6.0	842.0	27.42
187.0	829.0	7.0	836.0	28.01
189.8	816.0	7.0	823.0	28.59
192.7	802.0	12.0	814.0	29.18
195.5	801.0	11.0	812.0	29.75
198.3	804.0	9.0	813.0	30.32
201.2	796.0	9.0	805.0	30.91
204.0	789.0	12.0	801.0	31.47
206.8	792.0	12.0	804.0	32.03
209.7	796.0	12.0	808.0	32.62
212.5	790.0	17.0	807.0	33.18
215.3	784.0	16.0	800.0	33.74
218.2	792.0	15.0	807.0	34.32
221.0	787.0	14.0	801.0	34.88
223.8	786.0	14.0	800.0	35.44
226.7	781.0	15.0	796.0	36.01
229.5	782.0	18.0	800.0	36.57
232.3	782.0	21.0	803.0	37.13
235.2	776.0	19.0	795.0	37.70
238.0	768.0	21.0	789.0	38.25
240.8	753.0	23.0	776.0	38.78
243.7	743.0	23.0	766.0	39.33
246.5	713.0	22.0	735.0	39.84
249.3	680.0	22.0	702.0	40.32
252.2	653.0	24.0	677.0	40.80
255.0	620.0	26.0	646.0	41.24
257.8	598.0	23.0	621.0	41.67

Figure 1  
CPP Wind Tunnel Test Data for Instantaneous Puff Release

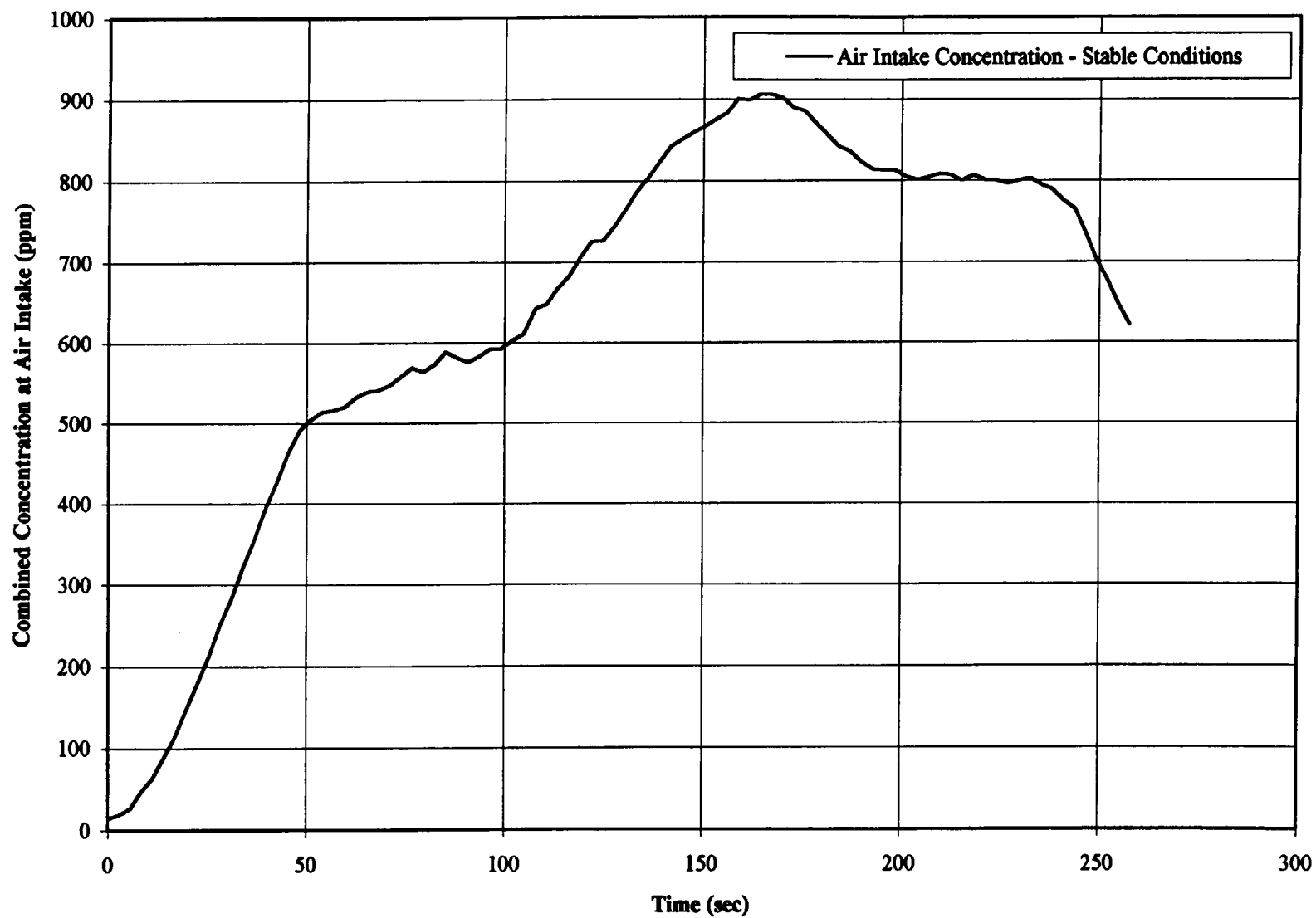


**Figure 2**  
**CPP Wind Tunnel Test Data for Evaporating Plume Release**

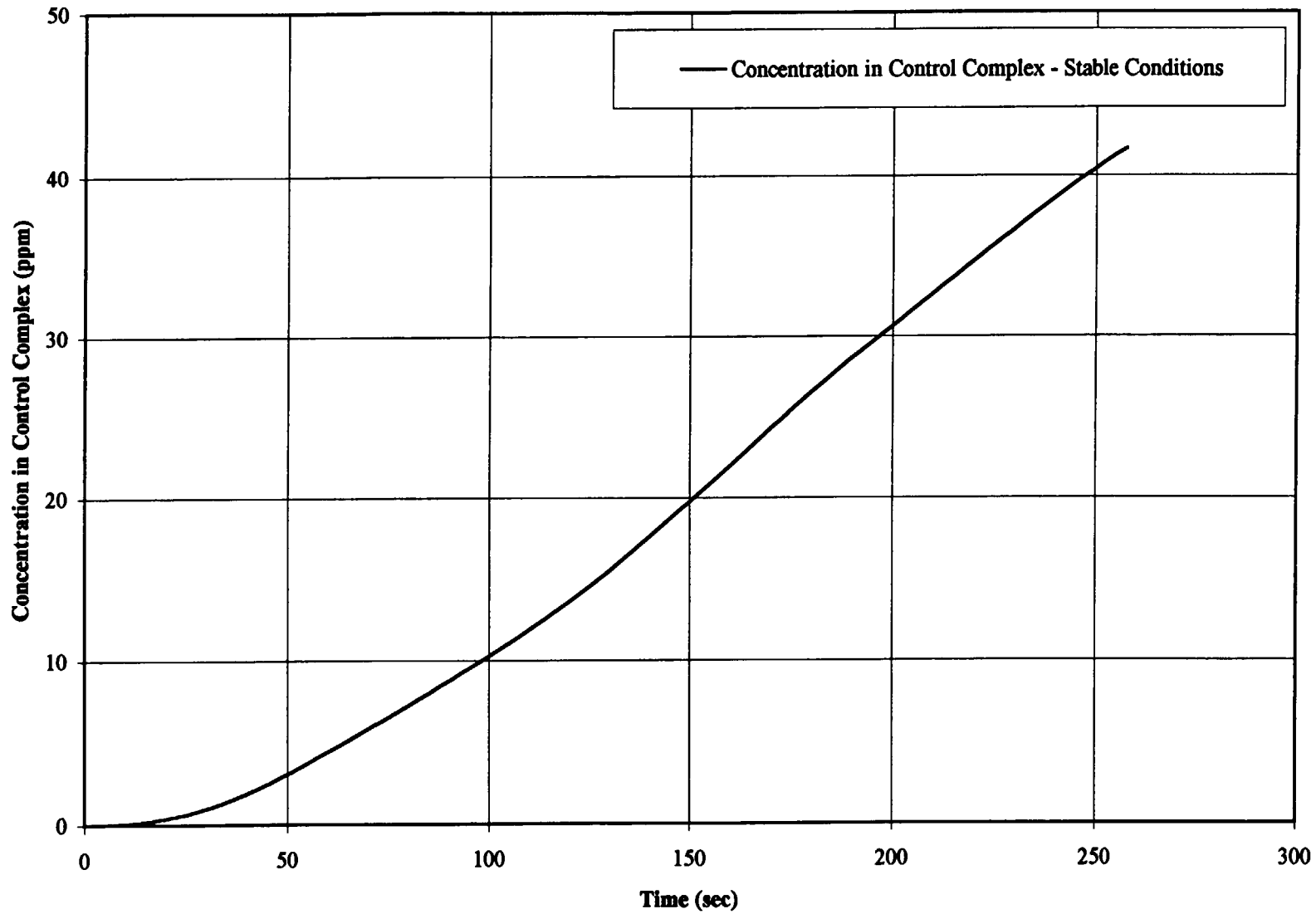


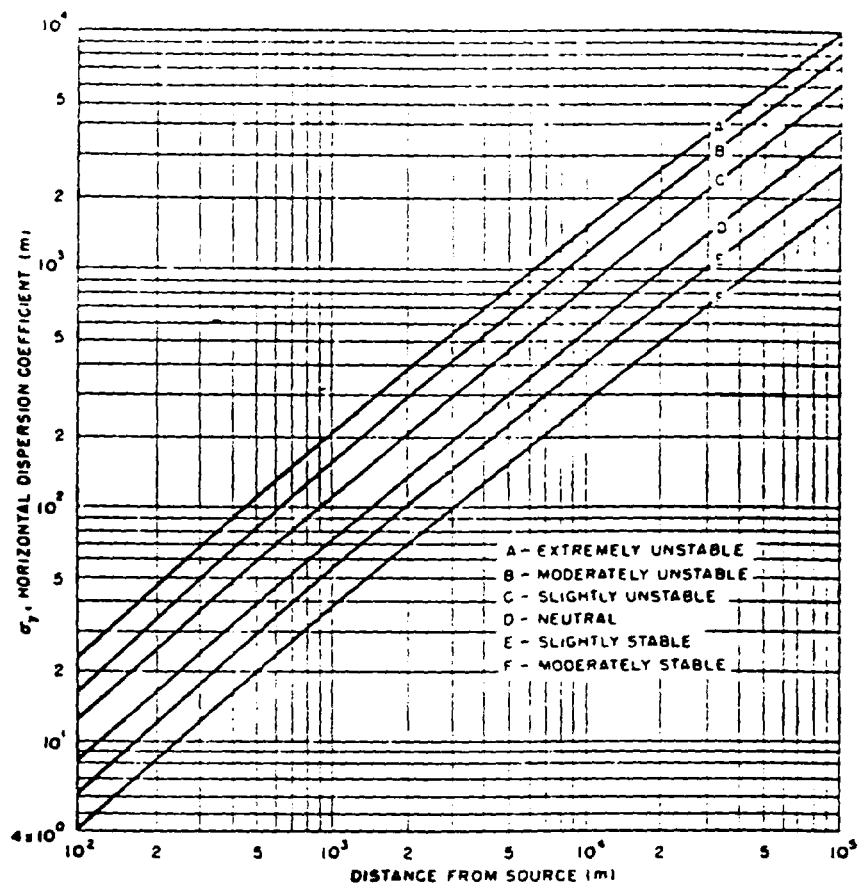


**Figure 3**  
**CPP Wind Tunnel Test Data for Combined Puff/Plume Release**



**Figure 4**  
**Control Complex Concentration based on CPP Wind Tunnel Test Data**





**Figure 1. Lateral diffusion without meander and building wake effects,  $\sigma_y$ , vs. downwind distance from source for Pasquill's turbulence types (atmospheric stability) (Ref. 7).**

The sigma values presented above are for unrestricted flow over relatively flat, uniform terrain. They may require modification before application in situations in which rough terrain or restricted flow conditions (e.g., within the confines of a narrow valley) must be considered or in coastal and desert areas. (See Ref. 12 for additional information.)

For purposes of estimating  $\sigma_y$  during extremely stable (G) atmospheric stability conditions, without plume meander or other lateral enhancement, the following approximation is appropriate:

$$\sigma_y(G) = \frac{2}{3} \sigma_y(F)$$

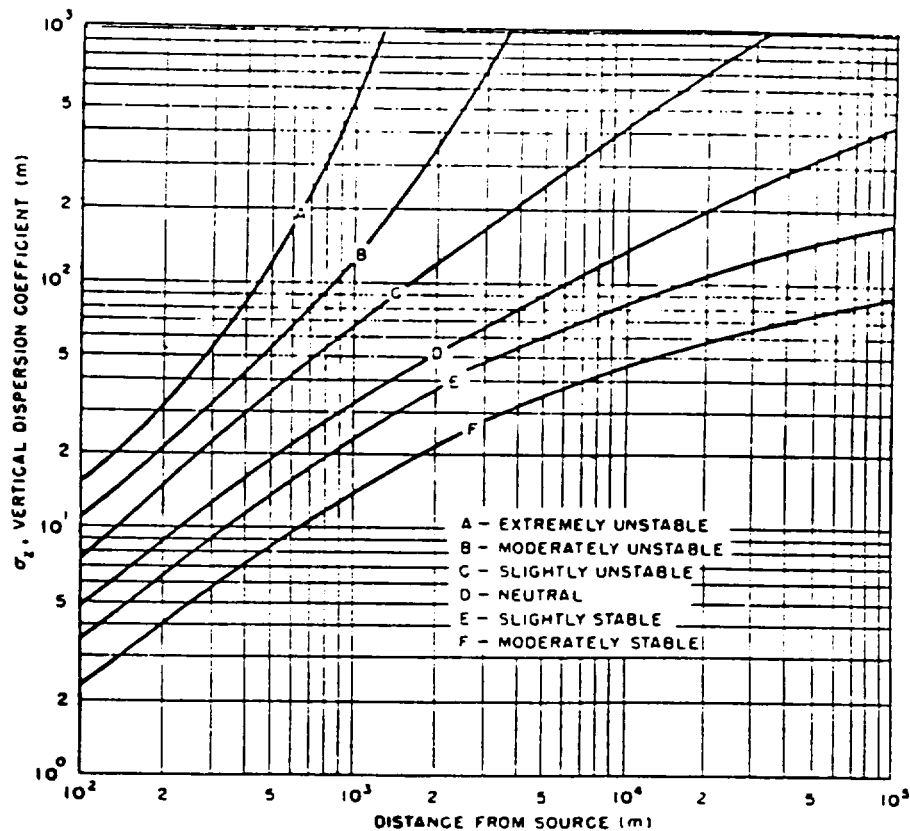


Figure 2. Vertical diffusion without meander and building wake effects,  $\sigma_z$ , vs. downwind distance from source for Pasquill's turbulence types (atmospheric stability) (Ref. 7).

The sigma values presented above are for unrestricted flow over relatively flat, uniform terrain. They may require modification before application in situations in which rough terrain or restricted flow conditions (e.g., within the confines of a narrow valley) must be considered or in coastal and desert areas. (See Ref. 12 for additional information.)

For purposes of estimating  $\sigma_z$  during extremely stable (G) atmospheric stability conditions, the following approximation is appropriate:

$$\sigma_z(G) = \frac{3}{5}\sigma_z(F)$$

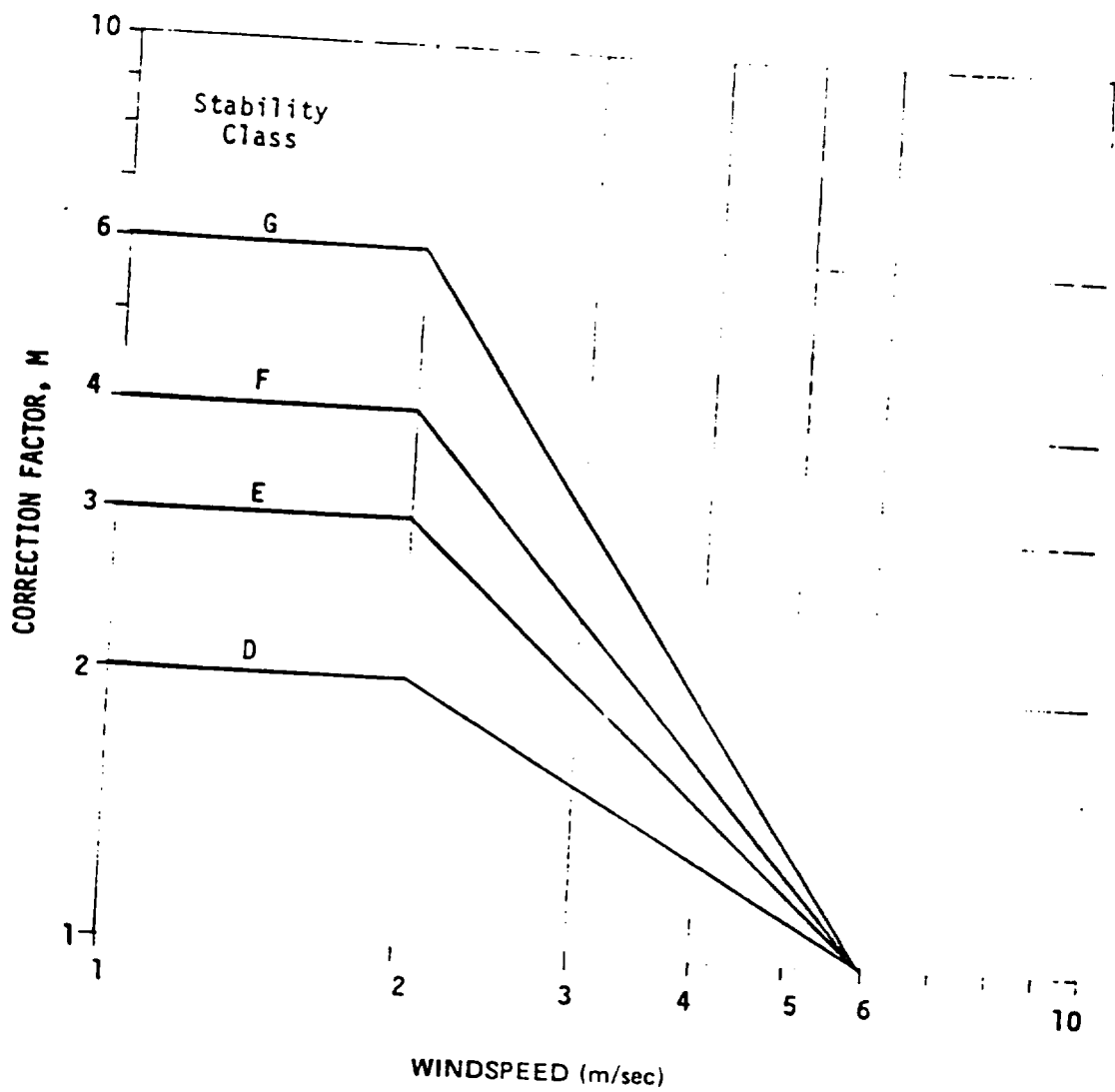


Figure 3. Correction factors for  $\sigma_y$  values by atmospheric stability class (see Appendix A to this guide).



**Attachment B**  
**Computer Code Output Files**

<u>Scenario: Chemical and Location</u>	<u>Relevant Parameters</u>	<u>filename</u> <u>(*out)</u>
<b>Instantaneous Container Failure: Nasal Detection with No Isolation</b>		
Cl <sub>2</sub> at Helper Cooling Tower	3 tons	3tcl2hct
Cl <sub>2</sub> at Helper Cooling Tower	9 tons	9tcl2hct
Cl <sub>2</sub> at Crystal River Units 4/5	1 ton instantaneous release with 3 tons continuous piping leakage	1tcl2cr4
SO <sub>2</sub> at Helper Cooling Tower	17.3 tons	173sohct
SO <sub>2</sub> at Helper Cooling Tower	50 tons	50so2hct
SO <sub>2</sub> at Crystal River Units 1/2	1.4 tons	14so2cr1
<b>Instantaneous Container Failure: Detection at Intake with Isolation</b>		
Cl <sub>2</sub> at Helper Cooling Tower	17 tons, 25 second delay time	cl2hct25
Cl <sub>2</sub> at Helper Cooling Tower	17 tons, 29 second delay time	cl2hct29
SO <sub>2</sub> at Helper Cooling Tower	50 tons, 30 second delay time	so2hct30
SO <sub>2</sub> at Helper Cooling Tower	50 tons, 33 second delay time	so2hct33
SO <sub>2</sub> at Crystal River Units 1/2	4.5 tons, 30 second delay time	so2cr130
<b>Valve Failure with Continuous Release: Detection at Intake with Isolation</b>		
SO <sub>2</sub> at Crystal River Units 1/2	30 tons, 30 second delay time	so2cr230
<b>Comparison with CPP Wind Tunnel Data: Instantaneous Container Failure with Nasal Detection and No Isolation</b>		
SO <sub>2</sub> at Crystal River Units 1/2	30 tons	30so2cr1



3 Ton Chlorine Release at Helper Cooling Tower  
Output file is 3tcl2hct.out

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Accident scenario is tank failure

Mass of spill, kg = 2721.60

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 70.90

Latent heat of chemical, J/kg = 288000.00

Specific heat of chemical, J/kg-K = 946.00

Liquid density of chemical, kg/m<sup>3</sup> = 1570.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Nasal detection

Detection concentration, ppm = 3.50

Ambient temperature, K = 305.60

Boiling temperature, K = 239.10

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 2.99

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.13

Vertical dispersion coefficient, m = 14.58

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

---

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	200.13	14.58



1.10	180.89	13.37
1.20	165.37	12.35
1.30	152.35	11.50
1.40	141.60	10.73
1.50	131.91	10.09
1.60	123.44	9.53
1.70	116.27	9.01
1.80	109.61	8.58
1.90	103.65	8.19
2.00	98.54	7.81
2.10	100.23	7.93
2.20	101.62	8.07
2.30	103.23	8.17
2.40	104.53	8.29
2.50	105.80	8.41
2.60	107.30	8.49
2.70	108.22	8.61
2.80	109.66	8.68
2.90	110.50	8.79
3.00	111.60	8.87
3.10	112.67	8.94
3.20	110.48	8.89
3.30	107.68	8.77
3.40	104.76	8.69
3.50	102.29	8.57
3.60	99.68	8.49
3.70	97.47	8.38
3.80	95.12	8.30
3.90	92.88	8.21
4.00	91.01	8.10
4.10	88.98	8.00
4.20	87.05	7.89
4.30	84.98	7.77
4.40	83.22	7.59
4.50	81.54	7.43
4.60	79.93	7.27
4.70	78.18	7.14
4.80	76.71	7.00
4.90	75.09	6.88
5.00	73.74	6.75
5.10	72.43	6.62
5.20	71.00	6.51
5.30	69.61	6.41
5.40	68.28	6.31
5.50	67.17	6.20
5.60	65.77	6.13
5.70	64.58	6.04
5.80	63.43	5.95
5.90	62.17	5.88
6.00	60.96	5.82



time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
854.00	182.30	0.00	0.00	0.00	0.00
855.00	181.30	0.00	0.00	0.00	0.00
856.00	180.30	0.00	0.00	0.00	0.00
857.00	179.30	0.00	0.00	0.00	0.00
858.00	178.30	0.00	0.00	0.00	0.00
859.00	177.30	0.00	0.00	0.00	0.00
860.00	176.30	0.00	0.00	0.00	0.00
861.00	175.30	0.00	0.00	0.00	0.00
862.00	174.30	0.00	0.00	0.00	0.00
863.00	173.30	0.00	0.00	0.00	0.00
864.00	172.30	0.00	0.00	0.00	0.00
865.00	171.30	0.01	0.00	0.01	0.00
866.00	170.30	0.01	0.00	0.01	0.00
867.00	169.30	0.01	0.00	0.01	0.00
868.00	168.30	0.01	0.00	0.01	0.00
869.00	167.30	0.01	0.00	0.01	0.00
870.00	166.30	0.01	0.00	0.01	0.00
871.00	165.30	0.01	0.00	0.01	0.00
872.00	164.30	0.01	0.00	0.01	0.00
873.00	163.30	0.02	0.00	0.02	0.00
874.00	162.30	0.02	0.00	0.02	0.00
875.00	161.30	0.02	0.00	0.02	0.00
876.00	160.30	0.02	0.00	0.02	0.00
877.00	159.30	0.03	0.00	0.03	0.00
878.00	158.30	0.03	0.00	0.03	0.00
879.00	157.30	0.03	0.00	0.03	0.00
880.00	156.30	0.04	0.00	0.04	0.00
881.00	155.30	0.04	0.00	0.04	0.00
882.00	154.30	0.05	0.00	0.05	0.00
883.00	153.30	0.05	0.00	0.05	0.00
884.00	152.30	0.06	0.00	0.06	0.00
885.00	151.30	0.07	0.00	0.07	0.00
886.00	150.30	0.08	0.00	0.08	0.00
887.00	149.30	0.09	0.00	0.09	0.00
888.00	148.30	0.10	0.00	0.10	0.00
889.00	147.30	0.11	0.00	0.11	0.00
890.00	146.30	0.13	0.00	0.13	0.00
891.00	145.30	0.14	0.00	0.14	0.00
892.00	144.30	0.16	0.00	0.16	0.00
893.00	143.30	0.18	0.00	0.18	0.00
894.00	142.30	0.20	0.00	0.20	0.00
895.00	141.30	0.23	0.00	0.23	0.00
896.00	140.30	0.26	0.00	0.26	0.00
897.00	139.30	0.29	0.00	0.29	0.00
898.00	138.30	0.32	0.00	0.32	0.00
899.00	137.30	0.36	0.00	0.36	0.00
900.00	136.30	0.40	0.00	0.40	0.00
901.00	135.30	0.45	0.00	0.45	0.00

902.00	134.30	0.50	0.00	0.50	0.00
903.00	133.30	0.56	0.00	0.56	0.00
904.00	132.30	0.62	0.00	0.62	0.00
905.00	131.30	0.69	0.00	0.69	0.00
906.00	130.30	0.76	0.00	0.76	0.00
907.00	129.30	0.85	0.00	0.85	0.00
908.00	128.30	0.94	0.00	0.94	0.00
909.00	127.30	1.05	0.00	1.05	0.00
910.00	126.30	1.16	0.00	1.16	0.00
911.00	125.30	1.28	0.00	1.28	0.00
912.00	124.30	1.42	0.00	1.42	0.00
913.00	123.30	1.57	0.00	1.57	0.00
914.00	122.30	1.73	0.00	1.73	0.00
915.00	121.30	1.91	0.00	1.91	0.00
916.00	120.30	2.11	0.00	2.11	0.01
917.00	119.30	2.33	0.00	2.33	0.01
918.00	118.30	2.56	0.00	2.56	0.01
919.00	117.30	2.82	0.00	2.82	0.01
920.00	116.30	3.10	0.00	3.10	0.01
921.00	115.30	3.40	0.00	3.40	0.01
922.00	114.30	3.73	0.00	3.73	0.01
923.00	113.30	4.09	0.00	4.09	0.01
924.00	112.30	4.48	0.00	4.48	0.01
925.00	111.30	4.91	0.00	4.91	0.01
926.00	110.30	5.37	0.00	5.37	0.02
927.00	109.30	5.87	0.00	5.87	0.02
928.00	108.30	6.41	0.00	6.41	0.02
929.00	107.30	7.00	0.00	7.00	0.02
930.00	106.30	7.63	0.00	7.63	0.02
931.00	105.30	8.31	0.00	8.31	0.02
932.00	104.30	9.05	0.00	9.05	0.03
933.00	103.30	9.84	0.00	9.84	0.03
934.00	102.30	10.70	0.00	10.70	0.03
935.00	101.30	11.62	0.00	11.62	0.03
936.00	100.30	12.60	0.00	12.60	0.04
937.00	99.30	13.67	0.00	13.67	0.04
938.00	98.30	14.80	0.00	14.80	0.05
939.00	97.30	16.03	0.00	16.03	0.05
940.00	96.30	17.33	0.00	17.33	0.05
941.00	95.30	18.73	0.00	18.73	0.06
942.00	94.30	20.23	0.00	20.23	0.06
943.00	93.30	21.82	0.00	21.82	0.07
944.00	92.30	23.53	0.00	23.53	0.08
945.00	91.30	25.35	0.00	25.35	0.08
946.00	90.30	27.28	0.00	27.28	0.09
947.00	89.30	29.34	0.00	29.34	0.10
948.00	88.30	31.53	0.00	31.53	0.11
949.00	87.30	33.85	0.00	33.85	0.11
950.00	86.30	36.32	0.00	36.32	0.12
951.00	85.30	38.93	0.00	38.93	0.13
952.00	84.30	41.70	0.00	41.70	0.14
953.00	83.30	44.63	0.00	44.63	0.16
954.00	82.30	47.73	0.00	47.73	0.17

955.00	81.30	51.00	0.00	51.00	0.18
956.00	80.30	54.45	0.00	54.45	0.20
957.00	79.30	58.08	0.00	58.08	0.21
958.00	78.30	61.91	0.00	61.91	0.23
959.00	77.30	65.94	0.00	65.94	0.24
960.00	76.30	70.17	0.00	70.17	0.26
961.00	75.30	74.62	0.00	74.62	0.28
962.00	74.30	79.28	0.00	79.28	0.30
963.00	73.30	84.17	0.00	84.17	0.32
964.00	72.30	89.28	0.00	89.28	0.35
965.00	71.30	94.63	0.00	94.63	0.37
966.00	70.30	100.21	0.00	100.21	0.40
967.00	69.30	106.04	0.00	106.04	0.43
968.00	68.30	111.40	0.00	111.40	0.45
969.00	67.30	111.94	0.00	111.94	0.48
970.00	66.30	112.48	0.00	112.48	0.51
971.00	65.30	113.01	0.00	113.01	0.54
972.00	64.30	113.54	0.00	113.54	0.57
973.00	63.30	114.06	0.00	114.06	0.60
974.00	62.30	114.58	0.00	114.58	0.63
975.00	61.30	115.09	0.00	115.09	0.66
976.00	60.30	115.60	0.00	115.60	0.69
977.00	59.30	116.09	0.00	116.09	0.72
978.00	58.30	116.59	0.00	116.59	0.75
979.00	57.30	117.07	0.00	117.07	0.78
980.00	56.30	117.55	0.00	117.55	0.81
981.00	55.30	118.02	0.00	118.02	0.84
982.00	54.30	118.49	0.00	118.49	0.87
983.00	53.30	118.95	0.00	118.95	0.90
984.00	52.30	119.40	0.00	119.40	0.93
985.00	51.30	119.85	0.00	119.85	0.96
986.00	50.30	120.29	0.00	120.29	1.00
987.00	49.30	120.72	0.00	120.72	1.03
988.00	48.30	121.14	0.00	121.14	1.06
989.00	47.30	121.56	0.00	121.56	1.09
990.00	46.30	121.97	0.00	121.97	1.12
991.00	45.30	122.37	0.00	122.37	1.15
992.00	44.30	122.77	0.00	122.77	1.18
993.00	43.30	123.15	0.00	123.15	1.22
994.00	42.30	123.53	0.00	123.53	1.25
995.00	41.30	123.91	0.00	123.91	1.28
996.00	40.30	124.27	0.00	124.27	1.31
997.00	39.30	124.63	0.00	124.63	1.34
998.00	38.30	124.98	0.00	124.98	1.38
999.00	37.30	125.32	0.00	125.32	1.41
1000.00	36.30	125.65	0.00	125.65	1.44
1001.00	35.30	125.97	0.00	125.97	1.47
1002.00	34.30	126.29	0.00	126.29	1.51
1003.00	33.30	126.59	0.00	126.59	1.54
1004.00	32.30	126.89	0.00	126.89	1.57
1005.00	31.30	127.18	0.00	127.18	1.60
1006.00	30.30	127.47	0.00	127.47	1.64
1007.00	29.30	127.74	0.00	127.74	1.67

1008.00	28.30	128.00	0.00	128.00	1.70
1009.00	27.30	128.26	0.00	128.26	1.73
1010.00	26.30	128.51	0.00	128.51	1.77
1011.00	25.30	128.75	0.00	128.75	1.80
1012.00	24.30	128.98	0.00	128.98	1.83
1013.00	23.30	129.20	0.00	129.20	1.87
1014.00	22.30	129.41	0.00	129.41	1.90
1015.00	21.30	129.61	0.00	129.61	1.93
1016.00	20.30	129.81	0.00	129.81	1.97
1017.00	19.30	129.99	0.00	129.99	2.00
1018.00	18.30	130.17	0.00	130.17	2.03
1019.00	17.30	130.33	0.00	130.33	2.07
1020.00	16.30	130.49	0.00	130.49	2.10
1021.00	15.30	130.64	0.00	130.64	2.13
1022.00	14.30	130.78	0.00	130.78	2.17
1023.00	13.30	130.91	0.00	130.91	2.20
1024.00	12.30	131.03	0.00	131.03	2.23
1025.00	11.30	131.14	0.00	131.14	2.27
1026.00	10.30	131.24	0.00	131.24	2.30
1027.00	9.30	131.34	0.00	131.34	2.33
1028.00	8.30	131.42	0.00	131.42	2.37
1029.00	7.30	131.49	0.00	131.49	2.40
1030.00	6.30	131.56	0.00	131.56	2.44
1031.00	5.30	131.61	0.00	131.61	2.47
1032.00	4.30	131.66	0.00	131.66	2.50
1033.00	3.30	131.69	0.00	131.69	2.54
1034.00	2.30	131.72	0.00	131.72	2.57
1035.00	1.30	131.74	0.00	131.74	2.60
1036.00	0.30	131.74	0.00	131.74	2.64
1037.00	-0.70	131.74	23.02	154.76	2.68
1038.00	-1.70	131.73	188.81	320.54	2.76
1039.00	-2.70	131.71	253.52	385.23	2.86
1040.00	-3.70	131.68	306.21	437.89	2.97
1041.00	-4.70	131.64	351.89	483.53	3.10
1042.00	-5.70	131.59	392.83	524.42	3.23
1043.00	-6.70	131.53	430.28	561.81	3.38
1044.00	-7.70	131.46	465.00	596.47	3.53
1045.00	-8.70	131.39	497.51	628.90	3.70
1046.00	-9.70	131.30	528.16	659.47	3.87
1047.00	-10.70	131.20	557.23	688.43	4.04
1048.00	-11.70	131.10	558.66	689.76	4.22
1049.00	-12.70	130.98	536.97	667.96	4.40
1050.00	-13.70	130.86	517.84	648.69	4.56
1051.00	-14.70	130.73	500.79	631.51	4.73
1052.00	-15.70	130.58	485.48	616.06	4.89
1053.00	-16.70	130.43	471.62	602.05	5.04
1054.00	-17.70	130.27	459.01	589.28	5.19
1055.00	-18.70	130.10	447.46	577.56	5.34
1056.00	-19.70	129.92	436.84	566.76	5.49
1057.00	-20.70	129.73	427.03	556.76	5.63
1058.00	-21.70	129.53	417.92	547.45	5.77
1059.00	-22.70	129.33	409.44	538.77	5.91
1060.00	-23.70	129.11	401.52	530.63	6.05



1061.00	-24.70	128.89	394.10	522.99	6.18
1062.00	-25.70	128.65	387.14	515.79	6.32
1063.00	-26.70	128.41	380.57	508.98	6.45
1064.00	-27.70	128.16	374.38	502.54	6.58
1065.00	-28.70	127.90	368.52	496.42	6.70
1066.00	-29.70	127.63	362.97	490.60	6.83
1067.00	-30.70	127.35	357.69	485.05	6.95
1068.00	-31.70	127.07	352.68	479.74	7.08
1069.00	-32.70	126.78	347.90	474.67	7.20
1070.00	-33.70	126.47	343.33	469.81	7.32
1071.00	-34.70	126.16	338.98	465.14	7.44
1072.00	-35.70	125.84	334.81	460.65	7.56
1073.00	-36.70	125.52	330.81	456.33	7.67
1074.00	-37.70	125.18	326.98	452.16	7.79
1075.00	-38.70	124.84	323.30	448.14	7.90
1076.00	-39.70	124.49	319.76	444.25	8.02
1077.00	-40.70	124.13	316.36	440.49	8.13
1078.00	-41.70	123.76	313.08	436.84	8.24
1079.00	-42.70	123.38	309.92	433.31	8.35
1080.00	-43.70	123.00	306.87	429.87	8.46
1081.00	-44.70	122.61	303.93	426.54	8.57
1082.00	-45.70	122.21	301.08	423.29	8.68
1083.00	-46.70	121.81	298.33	420.14	8.79
1084.00	-47.70	121.39	295.66	417.06	8.89
1085.00	-48.70	120.97	293.08	414.06	9.00
1086.00	-49.70	120.55	290.58	411.13	9.10
1087.00	-50.70	120.11	288.16	408.27	9.21
1088.00	-51.70	119.67	285.80	405.47	9.31
1089.00	-52.70	119.22	283.51	402.74	9.41
1090.00	-53.70	118.77	281.29	400.06	9.51
1091.00	-54.70	118.30	279.13	397.44	9.61
1092.00	-55.70	117.84	277.03	394.87	9.71
1093.00	-56.70	117.36	274.99	392.35	9.81
1094.00	-57.70	116.88	273.00	389.88	9.91
1095.00	-58.70	116.39	271.06	387.45	10.01
1096.00	-59.70	115.90	269.18	385.07	10.11
1097.00	-60.70	115.39	267.33	382.73	10.21
1098.00	-61.70	114.89	265.54	380.43	10.30
1099.00	-62.70	114.38	263.79	378.16	10.40
1100.00	-63.70	113.86	262.08	375.93	10.49
1101.00	-64.70	113.33	260.41	373.74	10.59
1102.00	-65.70	112.80	258.78	371.58	10.68
1103.00	-66.70	112.27	257.18	369.45	10.77
1104.00	-67.70	111.72	255.62	367.35	10.87
1105.00	-68.70	109.66	254.10	363.76	10.96
1106.00	-69.70	103.68	252.61	356.29	11.05
1107.00	-70.70	97.95	251.15	349.10	11.14
1108.00	-71.70	92.46	249.73	342.19	11.22
1109.00	-72.70	87.21	248.33	335.53	11.31
1110.00	-73.70	82.19	246.96	329.14	11.39
1111.00	-74.70	77.39	245.62	323.01	11.47
1112.00	-75.70	72.82	244.30	317.12	11.55
1113.00	-76.70	68.46	243.02	311.47	11.63

1114.00	-77.70	64.31	241.75	306.06	11.71
1115.00	-78.70	60.36	240.52	300.87	11.78
1116.00	-79.70	56.61	239.30	295.91	11.86
1117.00	-80.70	53.05	238.11	291.15	11.93
1118.00	-81.70	49.67	236.94	286.61	12.00
1119.00	-82.70	46.47	235.79	282.26	12.07
1120.00	-83.70	43.44	234.66	278.10	12.14
1121.00	-84.70	40.57	233.56	274.13	12.21
1122.00	-85.70	37.87	232.47	270.34	12.27
1123.00	-86.70	35.31	231.40	266.71	12.34
1124.00	-87.70	32.91	230.35	263.25	12.41
1125.00	-88.70	30.64	229.32	259.95	12.47
1126.00	-89.70	28.50	228.30	256.80	12.53
1127.00	-90.70	26.49	227.30	253.80	12.60
1128.00	-91.70	24.60	226.32	250.93	12.66
1129.00	-92.70	22.83	225.36	248.19	12.72
1130.00	-93.70	21.17	224.41	245.58	12.78
1131.00	-94.70	19.62	223.47	243.09	12.84
1132.00	-95.70	18.16	222.55	240.72	12.90
1133.00	-96.70	16.80	221.65	238.45	12.96
1134.00	-97.70	15.53	220.76	236.29	13.02
1135.00	-98.70	14.34	219.88	234.22	13.07
1136.00	-99.70	13.23	219.02	232.25	13.13
1137.00	-100.70	12.20	218.16	230.37	13.19
1138.00	-101.70	11.24	217.33	228.57	13.24
1139.00	-102.70	10.35	216.50	226.85	13.30
1140.00	-103.70	9.52	215.69	225.20	13.35
1141.00	-104.70	8.75	214.88	223.63	13.41
1142.00	-105.70	8.03	214.09	222.12	13.46
1143.00	-106.70	7.37	213.31	220.68	13.52
1144.00	-107.70	6.76	212.54	219.30	13.57
1145.00	-108.70	6.19	211.79	217.98	13.62
1146.00	-109.70	5.67	211.04	216.70	13.68
1147.00	-110.70	5.18	210.30	215.48	13.73
1148.00	-111.70	4.74	209.57	214.31	13.78
1149.00	-112.70	4.32	208.86	213.18	13.83
1150.00	-113.70	3.94	208.15	212.09	13.89
1151.00	-114.70	3.60	207.45	211.05	13.94
1152.00	-115.70	3.28	206.76	210.04	13.99
1153.00	-116.70	2.98	206.08	209.06	14.04
1154.00	-117.70	2.71	205.41	208.12	14.09
1155.00	-118.70	2.46	204.74	207.21	14.14
1156.00	-119.70	2.24	204.09	206.33	14.19
1157.00	-120.70	2.03	203.44	205.47	14.24
1158.00	-121.70	1.84	202.80	204.64	14.29
1159.00	-122.70	1.67	202.17	203.84	14.34
1160.00	-123.70	1.51	201.55	203.06	14.39
1161.00	-124.70	1.36	200.93	202.30	14.44
1162.00	-125.70	1.23	200.33	201.56	14.48
1163.00	-126.70	1.11	199.73	200.84	14.53
1164.00	-127.70	1.00	199.13	200.13	14.58
1165.00	-128.70	0.90	198.54	199.45	14.63
1166.00	-129.70	0.81	197.96	198.78	14.68

1167.00	-130.70	0.73	197.39	198.12	14.73
1168.00	-131.70	0.66	196.82	197.48	14.77
1169.00	-132.70	0.59	196.26	196.86	14.82
1170.00	-133.70	0.53	195.71	196.24	14.87
1171.00	-134.70	0.48	195.16	195.64	14.91
1172.00	-135.70	0.43	194.62	195.05	14.96
1173.00	-136.70	0.38	194.09	194.47	15.01
1174.00	-137.70	0.34	193.56	193.90	15.06
1175.00	-138.70	0.31	193.03	193.34	15.10
1176.00	-139.70	0.27	192.51	192.79	15.15
1177.00	-140.70	0.24	192.00	192.24	15.19
1178.00	-141.70	0.22	191.49	191.71	15.24
1179.00	-142.70	0.19	190.99	191.19	15.29
1180.00	-143.70	0.17	190.49	190.67	15.33
1181.00	-144.70	0.15	190.00	190.16	15.38
1182.00	-145.70	0.14	189.52	189.65	15.42
1183.00	-146.70	0.12	189.04	189.16	15.47
1184.00	-147.70	0.11	188.56	188.67	15.51
1185.00	-148.70	0.10	188.09	188.18	15.56
1186.00	-149.70	0.08	187.62	187.70	15.60
1187.00	-150.70	0.07	187.16	187.23	15.65
1188.00	-151.70	0.07	186.70	186.77	15.69
1189.00	-152.70	0.06	186.25	186.31	15.74
1190.00	-153.70	0.05	185.80	185.85	15.78
1191.00	-154.70	0.05	185.35	185.40	15.82
1192.00	-155.70	0.04	184.91	184.95	15.87
1193.00	-156.70	0.04	184.48	184.51	15.91
1194.00	-157.70	0.03	184.05	184.08	15.96
1195.00	-158.70	0.03	183.62	183.65	16.00
1196.00	-159.70	0.02	183.20	183.22	16.04
1197.00	-160.70	0.02	182.78	182.80	16.09
1198.00	-161.70	0.02	182.36	182.38	16.13
1199.00	-162.70	0.02	181.95	181.97	16.17
1200.00	-163.70	0.01	181.54	181.56	16.22
1201.00	-164.70	0.01	181.14	181.15	16.26
1202.00	-165.70	0.01	180.74	180.75	16.30
1203.00	-166.70	0.01	180.34	180.35	16.34
1204.00	-167.70	0.01	179.95	179.96	16.39
1205.00	-168.70	0.01	179.56	179.56	16.43
1206.00	-169.70	0.01	179.17	179.18	16.47
1207.00	-170.70	0.01	178.79	178.79	16.51
1208.00	-171.70	0.00	178.41	178.41	16.56
1209.00	-172.70	0.00	178.03	178.04	16.60
1210.00	-173.70	0.00	177.66	177.66	16.64
1211.00	-174.70	0.00	177.29	177.29	16.68
1212.00	-175.70	0.00	176.92	176.93	16.72
1213.00	-176.70	0.00	176.56	176.56	16.77
1214.00	-177.70	0.00	176.20	176.20	16.81
1215.00	-178.70	0.00	175.84	175.84	16.85
1216.00	-179.70	0.00	175.49	175.49	16.89
1217.00	-180.70	0.00	175.14	175.14	16.93
1218.00	-181.70	0.00	174.79	174.79	16.97
1219.00	-182.70	0.00	174.44	174.44	17.01



1220.00	-183.70	0.00	174.10	174.10	17.05
1221.00	-184.70	0.00	173.76	173.76	17.09
1222.00	-185.70	0.00	173.42	173.42	17.14
1223.00	-186.70	0.00	173.09	173.09	17.18
1224.00	-187.70	0.00	172.76	172.76	17.22
1225.00	-188.70	0.00	172.43	172.43	17.26
1226.00	-189.70	0.00	172.10	172.10	17.30
1227.00	-190.70	0.00	171.78	171.78	17.34
1228.00	-191.70	0.00	171.46	171.46	17.38
1229.00	-192.70	0.00	171.14	171.14	17.42
1230.00	-193.70	0.00	170.82	170.82	17.46
1231.00	-194.70	0.00	170.51	170.51	17.50
1232.00	-195.70	0.00	170.20	170.20	17.54
1233.00	-196.70	0.00	169.89	169.89	17.58
1234.00	-197.70	0.00	169.58	169.58	17.62
1235.00	-198.70	0.00	169.28	169.28	17.66
1236.00	-199.70	0.00	168.97	168.97	17.69
1237.00	-200.70	0.00	168.67	168.67	17.73
1238.00	-201.70	0.00	168.38	168.38	17.77
1239.00	-202.70	0.00	168.08	168.08	17.81
1240.00	-203.70	0.00	167.79	167.79	17.85
1241.00	-204.70	0.00	167.50	167.50	17.89
1242.00	-205.70	0.00	167.21	167.21	17.93
1243.00	-206.70	0.00	166.92	166.92	17.97
1244.00	-207.70	0.00	166.64	166.64	18.01
1245.00	-208.70	0.00	166.35	166.35	18.05
1246.00	-209.70	0.00	166.07	166.07	18.08
1247.00	-210.70	0.00	165.79	165.79	18.12
1248.00	-211.70	0.00	165.52	165.52	18.16
1249.00	-212.70	0.00	165.24	165.24	18.20
1250.00	-213.70	0.00	164.97	164.97	18.24
1251.00	-214.70	0.00	164.70	164.70	18.28
1252.00	-215.70	0.00	164.43	164.43	18.31
1253.00	-216.70	0.00	164.16	164.16	18.35
1254.00	-217.70	0.00	163.90	163.90	18.39
1255.00	-218.70	0.00	163.64	163.64	18.43
1256.00	-219.70	0.00	163.37	163.37	18.46
1257.00	-220.70	0.00	163.11	163.11	18.50
1258.00	-221.70	0.00	162.86	162.86	18.54
1259.00	-222.70	0.00	162.60	162.60	18.58
1260.00	-223.70	0.00	162.34	162.34	18.61
1261.00	-224.70	0.00	162.09	162.09	18.65
1262.00	-225.70	0.00	161.84	161.84	18.69
1263.00	-226.70	0.00	161.59	161.59	18.73
1264.00	-227.70	0.00	161.34	161.34	18.76
1265.00	-228.70	0.00	161.10	161.10	18.80
1266.00	-229.70	0.00	160.85	160.85	18.84
1267.00	-230.70	0.00	160.61	160.61	18.87
1268.00	-231.70	0.00	160.37	160.37	18.91
1269.00	-232.70	0.00	160.13	160.13	18.95
1270.00	-233.70	0.00	159.89	159.89	18.99
1271.00	-234.70	0.00	159.65	159.65	19.02
1272.00	-235.70	0.00	159.42	159.42	19.06



1273.00	-236.70	0.00	159.18	159.18	19.09
1274.00	-237.70	0.00	158.95	158.95	19.13
1275.00	-238.70	0.00	158.72	158.72	19.17
1276.00	-239.70	0.00	158.49	158.49	19.20
1277.00	-240.70	0.00	158.26	158.26	19.24
1278.00	-241.70	0.00	158.04	158.04	19.28
1279.00	-242.70	0.00	157.81	157.81	19.31
1280.00	-243.70	0.00	157.59	157.59	19.35
1281.00	-244.70	0.00	157.37	157.37	19.38
1282.00	-245.70	0.00	157.15	157.15	19.42
1283.00	-246.70	0.00	156.93	156.93	19.46
1284.00	-247.70	0.00	156.71	156.71	19.49

Initial flashing fraction = 0.218

Initial flashing mass = 594.490 kg

Release detected at 1044.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 1036.300 seconds

Wind speed for max CC concentration is 1.000 m/sec

Meander factor at this wind speed is 4.00

Hor. coeff. adjusted for meander = 117.909 m

Maximum CR concentration at 120.0 seconds after detection 14.58 ppm



9 Ton Chlorine Release at Helper Cooling Tower  
Output file is 9tcl2hct.out

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Accident scenario is tank failure

Mass of spill, kg = 8164.80

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 70.90

Latent heat of chemical, J/kg = 288000.00

Specific heat of chemical, J/kg-K = 946.00

Liquid density of chemical, kg/m<sup>3</sup> = 1570.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed

assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Nasal detection

Detection concentration, ppm = 3.50

Ambient temperature, K = 305.60

Boiling temperature, K = 239.10

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 4.31

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.27

Vertical dispersion coefficient, m = 14.91

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

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Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	916.07	32.26

1.10	698.46	30.93
1.20	583.23	29.36
1.30	514.46	27.80
1.40	468.25	26.32
1.50	429.44	25.13
1.60	399.40	23.88
1.70	373.13	22.78
1.80	351.08	21.72
1.90	331.40	20.76
2.00	313.72	19.90
2.10	318.46	20.28
2.20	323.03	20.64
2.30	326.40	21.06
2.40	329.61	21.46
2.50	332.67	21.84
2.60	335.60	22.20
2.70	338.39	22.55
2.80	342.16	22.80
2.90	344.73	23.11
3.00	347.18	23.40
3.10	349.53	23.68
3.20	340.26	23.62
3.30	331.76	23.34
3.40	321.72	23.22
3.50	313.23	23.03
3.60	304.25	22.91
3.70	297.60	22.65
3.80	289.50	22.52
3.90	282.68	22.31
4.00	276.19	22.08
4.10	269.19	21.89
4.20	263.33	21.59
4.30	256.96	21.23
4.40	251.63	20.76
4.50	246.53	20.31
4.60	241.65	19.89
4.70	236.97	19.48
4.80	231.80	19.14
4.90	227.51	18.76
5.00	223.38	18.40
5.10	219.42	18.05
5.20	215.60	17.71
5.30	211.92	17.39
5.40	207.78	17.13
5.50	204.37	16.83
5.60	201.67	16.49
5.70	197.92	16.26
5.80	194.85	15.98
5.90	191.88	15.72
6.00	188.48	15.52

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Time history for limiting wind speed of 1.00 m/sec



time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
846.00	190.30	0.00	0.00	0.00	0.00
847.00	189.30	0.00	0.00	0.00	0.00
848.00	188.30	0.00	0.00	0.00	0.00
849.00	187.30	0.00	0.00	0.00	0.00
850.00	186.30	0.00	0.00	0.00	0.00
851.00	185.30	0.00	0.00	0.00	0.00
852.00	184.30	0.00	0.00	0.00	0.00
853.00	183.30	0.00	0.00	0.00	0.00
854.00	182.30	0.00	0.00	0.00	0.00
855.00	181.30	0.00	0.00	0.00	0.00
856.00	180.30	0.00	0.00	0.00	0.00
857.00	179.30	0.01	0.00	0.01	0.00
858.00	178.30	0.01	0.00	0.01	0.00
859.00	177.30	0.01	0.00	0.01	0.00
860.00	176.30	0.01	0.00	0.01	0.00
861.00	175.30	0.01	0.00	0.01	0.00
862.00	174.30	0.01	0.00	0.01	0.00
863.00	173.30	0.01	0.00	0.01	0.00
864.00	172.30	0.01	0.00	0.01	0.00
865.00	171.30	0.02	0.00	0.02	0.00
866.00	170.30	0.02	0.00	0.02	0.00
867.00	169.30	0.02	0.00	0.02	0.00
868.00	168.30	0.02	0.00	0.02	0.00
869.00	167.30	0.03	0.00	0.03	0.00
870.00	166.30	0.03	0.00	0.03	0.00
871.00	165.30	0.04	0.00	0.04	0.00
872.00	164.30	0.04	0.00	0.04	0.00
873.00	163.30	0.05	0.00	0.05	0.00
874.00	162.30	0.05	0.00	0.05	0.00
875.00	161.30	0.06	0.00	0.06	0.00
876.00	160.30	0.07	0.00	0.07	0.00
877.00	159.30	0.08	0.00	0.08	0.00
878.00	158.30	0.09	0.00	0.09	0.00
879.00	157.30	0.10	0.00	0.10	0.00
880.00	156.30	0.12	0.00	0.12	0.00
881.00	155.30	0.13	0.00	0.13	0.00
882.00	154.30	0.15	0.00	0.15	0.00
883.00	153.30	0.17	0.00	0.17	0.00
884.00	152.30	0.19	0.00	0.19	0.00
885.00	151.30	0.22	0.00	0.22	0.00
886.00	150.30	0.25	0.00	0.25	0.00
887.00	149.30	0.28	0.00	0.28	0.00
888.00	148.30	0.31	0.00	0.31	0.00
889.00	147.30	0.35	0.00	0.35	0.00
890.00	146.30	0.40	0.00	0.40	0.00
891.00	145.30	0.45	0.00	0.45	0.00
892.00	144.30	0.50	0.00	0.50	0.00
893.00	143.30	0.56	0.00	0.56	0.00

894.00	142.30	0.63	0.00	0.63	0.00
895.00	141.30	0.71	0.00	0.71	0.00
896.00	140.30	0.79	0.00	0.79	0.00
897.00	139.30	0.89	0.00	0.89	0.00
898.00	138.30	0.99	0.00	0.99	0.00
899.00	137.30	1.11	0.00	1.11	0.00
900.00	136.30	1.23	0.00	1.23	0.00
901.00	135.30	1.38	0.00	1.38	0.00
902.00	134.30	1.53	0.00	1.53	0.00
903.00	133.30	1.71	0.00	1.71	0.00
904.00	132.30	1.90	0.00	1.90	0.00
905.00	131.30	2.11	0.00	2.11	0.01
906.00	130.30	2.35	0.00	2.35	0.01
907.00	129.30	2.61	0.00	2.61	0.01
908.00	128.30	2.89	0.00	2.89	0.01
909.00	127.30	3.20	0.00	3.20	0.01
910.00	126.30	3.55	0.00	3.55	0.01
911.00	125.30	3.92	0.00	3.92	0.01
912.00	124.30	4.34	0.00	4.34	0.01
913.00	123.30	4.79	0.00	4.79	0.01
914.00	122.30	5.29	0.00	5.29	0.01
915.00	121.30	5.83	0.00	5.83	0.02
916.00	120.30	6.43	0.00	6.43	0.02
917.00	119.30	7.08	0.00	7.08	0.02
918.00	118.30	7.79	0.00	7.79	0.02
919.00	117.30	8.56	0.00	8.56	0.02
920.00	116.30	9.41	0.00	9.41	0.03
921.00	115.30	10.32	0.00	10.32	0.03
922.00	114.30	11.32	0.00	11.32	0.03
923.00	113.30	12.41	0.00	12.41	0.03
924.00	112.30	13.58	0.00	13.58	0.04
925.00	111.30	14.86	0.00	14.86	0.04
926.00	110.30	16.25	0.00	16.25	0.05
927.00	109.30	17.74	0.00	17.74	0.05
928.00	108.30	19.37	0.00	19.37	0.06
929.00	107.30	21.12	0.00	21.12	0.06
930.00	106.30	23.01	0.00	23.01	0.07
931.00	105.30	25.06	0.00	25.06	0.07
932.00	104.30	27.26	0.00	27.26	0.08
933.00	103.30	29.63	0.00	29.63	0.09
934.00	102.30	32.18	0.00	32.18	0.10
935.00	101.30	34.93	0.00	34.93	0.11
936.00	100.30	37.88	0.00	37.88	0.12
937.00	99.30	41.04	0.00	41.04	0.13
938.00	98.30	44.43	0.00	44.43	0.14
939.00	97.30	48.07	0.00	48.07	0.15
940.00	96.30	51.96	0.00	51.96	0.16
941.00	95.30	56.11	0.00	56.11	0.18
942.00	94.30	60.56	0.00	60.56	0.19
943.00	93.30	65.30	0.00	65.30	0.21
944.00	92.30	70.36	0.00	70.36	0.23
945.00	91.30	75.75	0.00	75.75	0.25
946.00	90.30	81.48	0.00	81.48	0.27

947.00	89.30	87.58	0.00	87.58	0.29
948.00	88.30	94.06	0.00	94.06	0.32
949.00	87.30	100.94	0.00	100.94	0.34
950.00	86.30	108.24	0.00	108.24	0.37
951.00	85.30	115.97	0.00	115.97	0.40
952.00	84.30	124.15	0.00	124.15	0.43
953.00	83.30	132.80	0.00	132.80	0.47
954.00	82.30	141.94	0.00	141.94	0.50
955.00	81.30	151.59	0.00	151.59	0.54
956.00	80.30	161.76	0.00	161.76	0.59
957.00	79.30	172.48	0.00	172.48	0.63
958.00	78.30	183.76	0.00	183.76	0.68
959.00	77.30	195.62	0.00	195.62	0.73
960.00	76.30	208.08	0.00	208.08	0.78
961.00	75.30	221.15	0.00	221.15	0.84
962.00	74.30	234.86	0.00	234.86	0.90
963.00	73.30	249.21	0.00	249.21	0.97
964.00	72.30	264.23	0.00	264.23	1.03
965.00	71.30	279.93	0.00	279.93	1.11
966.00	70.30	296.33	0.00	296.33	1.18
967.00	69.30	313.43	0.00	313.43	1.27
968.00	68.30	326.86	0.00	326.86	1.35
969.00	67.30	328.45	0.00	328.45	1.44
970.00	66.30	330.04	0.00	330.04	1.52
971.00	65.30	331.60	0.00	331.60	1.61
972.00	64.30	333.15	0.00	333.15	1.69
973.00	63.30	334.68	0.00	334.68	1.78
974.00	62.30	336.20	0.00	336.20	1.87
975.00	61.30	337.70	0.00	337.70	1.95
976.00	60.30	339.18	0.00	339.18	2.04
977.00	59.30	340.64	0.00	340.64	2.13
978.00	58.30	342.08	0.00	342.08	2.22
979.00	57.30	343.51	0.00	343.51	2.31
980.00	56.30	344.91	0.00	344.91	2.40
981.00	55.30	346.30	0.00	346.30	2.49
982.00	54.30	347.67	0.00	347.67	2.58
983.00	53.30	349.02	0.00	349.02	2.67
984.00	52.30	350.34	0.00	350.34	2.76
985.00	51.30	351.65	0.00	351.65	2.85
986.00	50.30	352.94	0.00	352.94	2.94
987.00	49.30	354.21	0.00	354.21	3.03
988.00	48.30	355.45	0.00	355.45	3.12
989.00	47.30	356.67	0.00	356.67	3.21
990.00	46.30	357.88	0.00	357.88	3.31
991.00	45.30	359.06	0.00	359.06	3.40
992.00	44.30	360.22	0.00	360.22	3.49
993.00	43.30	361.35	0.00	361.35	3.58
994.00	42.30	362.47	0.00	362.47	3.68
995.00	41.30	363.56	0.00	363.56	3.77
996.00	40.30	364.63	0.00	364.63	3.87
997.00	39.30	365.67	0.00	365.67	3.96
998.00	38.30	366.70	0.00	366.70	4.05
999.00	37.30	367.69	0.00	367.69	4.15

1000.00	36.30	368.67	0.00	368.67	4.24
1001.00	35.30	369.62	0.00	369.62	4.34
1002.00	34.30	370.55	0.00	370.55	4.43
1003.00	33.30	371.45	0.00	371.45	4.53
1004.00	32.30	372.32	0.00	372.32	4.63
1005.00	31.30	373.18	0.00	373.18	4.72
1006.00	30.30	374.01	0.00	374.01	4.82
1007.00	29.30	374.81	0.00	374.81	4.91
1008.00	28.30	375.58	0.00	375.58	5.01
1009.00	27.30	376.34	0.00	376.34	5.11
1010.00	26.30	377.06	0.00	377.06	5.20
1011.00	25.30	377.76	0.00	377.76	5.30
1012.00	24.30	378.44	0.00	378.44	5.40
1013.00	23.30	379.09	0.00	379.09	5.50
1014.00	22.30	379.71	0.00	379.71	5.59
1015.00	21.30	380.30	0.00	380.30	5.69
1016.00	20.30	380.87	0.00	380.87	5.79
1017.00	19.30	381.42	0.00	381.42	5.89
1018.00	18.30	381.93	0.00	381.93	5.98
1019.00	17.30	382.42	0.00	382.42	6.08
1020.00	16.30	382.88	0.00	382.88	6.18
1021.00	15.30	383.32	0.00	383.32	6.28
1022.00	14.30	383.73	0.00	383.73	6.38
1023.00	13.30	384.11	0.00	384.11	6.47
1024.00	12.30	384.46	0.00	384.46	6.57
1025.00	11.30	384.79	0.00	384.79	6.67
1026.00	10.30	385.09	0.00	385.09	6.77
1027.00	9.30	385.36	0.00	385.36	6.87
1028.00	8.30	385.60	0.00	385.60	6.97
1029.00	7.30	385.82	0.00	385.82	7.07
1030.00	6.30	386.01	0.00	386.01	7.16
1031.00	5.30	386.17	0.00	386.17	7.26
1032.00	4.30	386.30	0.00	386.30	7.36
1033.00	3.30	386.41	0.00	386.41	7.46
1034.00	2.30	386.49	0.00	386.49	7.56
1035.00	1.30	386.54	0.00	386.54	7.66
1036.00	0.30	386.56	0.00	386.56	7.76
1037.00	-0.70	386.55	46.82	433.38	7.87
1038.00	-1.70	386.52	327.70	714.22	8.05
1039.00	-2.70	386.46	435.20	821.66	8.26
1040.00	-3.70	386.37	523.69	910.06	8.50
1041.00	-4.70	386.25	600.80	987.05	8.75
1042.00	-5.70	386.11	670.18	1056.29	9.02
1043.00	-6.70	385.94	733.86	1119.80	9.31
1044.00	-7.70	385.74	793.10	1178.84	9.62
1045.00	-8.70	385.51	848.74	1234.25	9.94
1046.00	-9.70	385.25	901.39	1286.65	10.27
1047.00	-10.70	384.97	951.49	1336.46	10.61
1048.00	-11.70	384.66	999.36	1384.03	10.97
1049.00	-12.70	384.32	1045.29	1429.62	11.34
1050.00	-13.70	383.96	1089.48	1473.44	11.72
1051.00	-14.70	383.57	1132.09	1515.66	12.11
1052.00	-15.70	383.15	1173.28	1556.43	12.52

1053.00	-16.70	382.70	1213.17	1595.87	12.93
1054.00	-17.70	382.23	1251.85	1634.08	13.35
1055.00	-18.70	381.73	1289.41	1671.14	13.78
1056.00	-19.70	381.20	1281.75	1662.96	14.21
1057.00	-20.70	380.65	1252.95	1633.60	14.63
1058.00	-21.70	380.07	1226.24	1606.31	15.05
1059.00	-22.70	379.46	1201.36	1580.82	15.45
1060.00	-23.70	378.83	1178.13	1556.96	15.85
1061.00	-24.70	378.17	1156.36	1534.53	16.25
1062.00	-25.70	377.49	1135.91	1513.40	16.64
1063.00	-26.70	376.78	1116.66	1493.43	17.02
1064.00	-27.70	376.04	1098.48	1474.52	17.40
1065.00	-28.70	375.28	1081.29	1456.57	17.78
1066.00	-29.70	374.49	1064.99	1439.48	18.15
1067.00	-30.70	373.68	1049.52	1423.20	18.51
1068.00	-31.70	372.84	1034.80	1407.64	18.88
1069.00	-32.70	371.98	1020.78	1392.75	19.23
1070.00	-33.70	371.09	1007.40	1378.48	19.59
1071.00	-34.70	370.18	994.61	1364.79	19.94
1072.00	-35.70	369.24	982.37	1351.62	20.28
1073.00	-36.70	368.28	970.65	1338.93	20.63
1074.00	-37.70	367.30	959.41	1326.71	20.97
1075.00	-38.70	366.29	948.61	1314.90	21.30
1076.00	-39.70	365.26	938.24	1303.49	21.64
1077.00	-40.70	364.20	928.25	1292.45	21.97
1078.00	-41.70	363.13	918.63	1281.76	22.30
1079.00	-42.70	362.03	909.36	1271.38	22.62
1080.00	-43.70	360.90	900.41	1261.31	22.94
1081.00	-44.70	359.76	891.77	1251.52	23.26
1082.00	-45.70	358.59	883.42	1242.01	23.58
1083.00	-46.70	357.40	875.34	1232.74	23.90
1084.00	-47.70	356.19	867.52	1223.71	24.21
1085.00	-48.70	354.96	859.95	1214.90	24.52
1086.00	-49.70	353.70	852.61	1206.31	24.83
1087.00	-50.70	352.43	845.49	1197.92	25.13
1088.00	-51.70	351.13	838.58	1189.71	25.43
1089.00	-52.70	349.81	831.87	1181.69	25.73
1090.00	-53.70	348.48	825.36	1173.84	26.03
1091.00	-54.70	347.12	819.02	1166.14	26.33
1092.00	-55.70	345.75	812.86	1158.61	26.63
1093.00	-56.70	344.35	806.86	1151.22	26.92
1094.00	-57.70	342.94	801.03	1143.97	27.21
1095.00	-58.70	341.51	795.34	1136.85	27.50
1096.00	-59.70	340.05	789.80	1129.86	27.78
1097.00	-60.70	338.59	784.40	1122.98	28.07
1098.00	-61.70	337.10	779.13	1116.23	28.35
1099.00	-62.70	335.59	773.99	1109.58	28.63
1100.00	-63.70	334.07	768.97	1103.05	28.91
1101.00	-64.70	332.53	764.07	1096.61	29.19
1102.00	-65.70	330.98	759.29	1090.27	29.47
1103.00	-66.70	329.40	754.61	1084.02	29.74
1104.00	-67.70	327.82	750.04	1077.86	30.02
1105.00	-68.70	324.04	745.57	1069.61	30.29



1106.00	-69.70	306.50	741.20	1047.70	30.55
1107.00	-70.70	289.69	736.92	1026.61	30.81
1108.00	-71.70	273.57	732.73	1006.30	31.06
1109.00	-72.70	258.14	728.63	986.78	31.31
1110.00	-73.70	243.39	724.62	968.01	31.56
1111.00	-74.70	229.30	720.68	949.98	31.80
1112.00	-75.70	215.85	716.83	932.67	32.03
1113.00	-76.70	203.02	713.05	916.07	32.26
1114.00	-77.70	190.81	709.34	900.15	32.49
1115.00	-78.70	179.18	705.71	884.89	32.71
1116.00	-79.70	168.13	702.14	870.27	32.93
1117.00	-80.70	157.63	698.65	856.28	33.14
1118.00	-81.70	147.67	695.22	842.88	33.35
1119.00	-82.70	138.23	691.85	830.07	33.56
1120.00	-83.70	129.28	688.54	817.82	33.76
1121.00	-84.70	120.82	685.29	806.11	33.96
1122.00	-85.70	112.82	682.10	794.92	34.16
1123.00	-86.70	105.27	678.96	784.23	34.36
1124.00	-87.70	98.14	675.88	774.02	34.55
1125.00	-88.70	91.43	672.85	764.28	34.74
1126.00	-89.70	85.10	669.87	754.97	34.93
1127.00	-90.70	79.15	666.95	746.09	35.11
1128.00	-91.70	73.55	664.07	737.62	35.29
1129.00	-92.70	68.30	661.23	729.53	35.48
1130.00	-93.70	63.37	658.45	721.82	35.65
1131.00	-94.70	58.75	655.71	714.45	35.83
1132.00	-95.70	54.42	653.01	707.43	36.01
1133.00	-96.70	50.37	650.35	700.72	36.18
1134.00	-97.70	46.58	647.74	694.32	36.35
1135.00	-98.70	43.05	645.16	688.21	36.52
1136.00	-99.70	39.75	642.63	682.37	36.69
1137.00	-100.70	36.67	640.13	676.80	36.85
1138.00	-101.70	33.81	637.67	671.47	37.02
1139.00	-102.70	31.14	635.24	666.38	37.18
1140.00	-103.70	28.66	632.85	661.51	37.35
1141.00	-104.70	26.36	630.50	656.86	37.51
1142.00	-105.70	24.22	628.18	652.40	37.67
1143.00	-106.70	22.24	625.89	648.13	37.83
1144.00	-107.70	20.40	623.64	644.04	37.98
1145.00	-108.70	18.70	621.41	640.11	38.14
1146.00	-109.70	17.13	619.22	636.35	38.30
1147.00	-110.70	15.68	617.05	632.73	38.45
1148.00	-111.70	14.34	614.92	629.26	38.60
1149.00	-112.70	13.10	612.82	625.92	38.76
1150.00	-113.70	11.96	610.74	622.70	38.91
1151.00	-114.70	10.91	608.69	619.60	39.06
1152.00	-115.70	9.95	606.66	616.61	39.21
1153.00	-116.70	9.06	604.67	613.73	39.36
1154.00	-117.70	8.25	602.70	610.94	39.51
1155.00	-118.70	7.50	600.75	608.25	39.66
1156.00	-119.70	6.81	598.83	605.64	39.80
1157.00	-120.70	6.19	596.93	603.12	39.95
1158.00	-121.70	5.61	595.06	600.67	40.10



1159.00	-122.70	5.09	593.21	598.29	40.24
1160.00	-123.70	4.61	591.38	595.98	40.39
1161.00	-124.70	4.17	589.57	593.74	40.53
1162.00	-125.70	3.77	587.79	591.56	40.67
1163.00	-126.70	3.41	586.02	589.43	40.82
1164.00	-127.70	3.07	584.28	587.36	40.96
1165.00	-128.70	2.77	582.56	585.33	41.10
1166.00	-129.70	2.50	580.86	583.36	41.24
1167.00	-130.70	2.25	579.17	581.43	41.38
1168.00	-131.70	2.03	577.51	579.54	41.52
1169.00	-132.70	1.82	575.87	577.69	41.66
1170.00	-133.70	1.64	574.24	575.88	41.80
1171.00	-134.70	1.47	572.64	574.10	41.94
1172.00	-135.70	1.32	571.05	572.36	42.08
1173.00	-136.70	1.18	569.47	570.66	42.22
1174.00	-137.70	1.06	567.92	568.98	42.35
1175.00	-138.70	0.95	566.38	567.33	42.49
1176.00	-139.70	0.85	564.86	565.71	42.63
1177.00	-140.70	0.76	563.36	564.11	42.76
1178.00	-141.70	0.68	561.87	562.54	42.90
1179.00	-142.70	0.60	560.40	561.00	43.03
1180.00	-143.70	0.54	558.94	559.48	43.17
1181.00	-144.70	0.48	557.50	557.97	43.30
1182.00	-145.70	0.43	556.07	556.49	43.43
1183.00	-146.70	0.38	554.66	555.04	43.57
1184.00	-147.70	0.34	553.26	553.59	43.70
1185.00	-148.70	0.30	551.88	552.17	43.83
1186.00	-149.70	0.26	550.51	550.77	43.96
1187.00	-150.70	0.23	549.15	549.38	44.10
1188.00	-151.70	0.21	547.81	548.01	44.23
1189.00	-152.70	0.18	546.48	546.66	44.36
1190.00	-153.70	0.16	545.16	545.32	44.49
1191.00	-154.70	0.14	543.86	544.00	44.62
1192.00	-155.70	0.13	542.57	542.69	44.75
1193.00	-156.70	0.11	541.29	541.40	44.88
1194.00	-157.70	0.10	540.02	540.12	45.01
1195.00	-158.70	0.09	538.77	538.85	45.13
1196.00	-159.70	0.08	537.53	537.60	45.26
1197.00	-160.70	0.07	536.29	536.36	45.39
1198.00	-161.70	0.06	535.08	535.13	45.52
1199.00	-162.70	0.05	533.87	533.92	45.65
1200.00	-163.70	0.05	532.67	532.72	45.77
1201.00	-164.70	0.04	531.49	531.52	45.90
1202.00	-165.70	0.03	530.31	530.35	46.02
1203.00	-166.70	0.03	529.15	529.18	46.15
1204.00	-167.70	0.03	527.99	528.02	46.28
1205.00	-168.70	0.02	526.85	526.87	46.40
1206.00	-169.70	0.02	525.72	525.74	46.53
1207.00	-170.70	0.02	524.59	524.61	46.65
1208.00	-171.70	0.02	523.48	523.49	46.77
1209.00	-172.70	0.01	522.37	522.39	46.90
1210.00	-173.70	0.01	521.28	521.29	47.02
1211.00	-174.70	0.01	520.20	520.21	47.14



1212.00	-175.70	0.01	519.12	519.13	47.27
1213.00	-176.70	0.01	518.05	518.06	47.39
1214.00	-177.70	0.01	517.00	517.00	47.51
1215.00	-178.70	0.01	515.95	515.95	47.63
1216.00	-179.70	0.00	514.91	514.91	47.76
1217.00	-180.70	0.00	513.88	513.88	47.88
1218.00	-181.70	0.00	512.86	512.86	48.00
1219.00	-182.70	0.00	511.84	511.85	48.12
1220.00	-183.70	0.00	510.84	510.84	48.24
1221.00	-184.70	0.00	509.84	509.84	48.36
1222.00	-185.70	0.00	508.85	508.85	48.48
1223.00	-186.70	0.00	507.87	507.87	48.60
1224.00	-187.70	0.00	506.90	506.90	48.72
1225.00	-188.70	0.00	505.93	505.93	48.84
1226.00	-189.70	0.00	504.97	504.97	48.96
1227.00	-190.70	0.00	504.02	504.02	49.07
1228.00	-191.70	0.00	503.08	503.08	49.19
1229.00	-192.70	0.00	502.14	502.14	49.31
1230.00	-193.70	0.00	501.22	501.22	49.43
1231.00	-194.70	0.00	500.29	500.30	49.55
1232.00	-195.70	0.00	499.38	499.38	49.66
1233.00	-196.70	0.00	498.47	498.47	49.78

Initial flashing fraction = 0.218

Initial flashing mass = 1783.470 kg

Release detected at 993.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 1036.300 seconds

Wind speed for max CC concentration is 1.000 m/sec

Meander factor at this wind speed is 4.00

Hor. coeff. adjusted for meander = 117.909 m

Maximum CR concentration at 120.0 seconds after detection 32.26 ppm

**1 Ton Chlorine Release at Crystal River 4/5**Output file is 1tcl2cr4.out

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Accident scenario is tank failure

Mass of spill, kg = 907.20

Mass available for leakage, kg = 2721.60

Valve vapor leakage rate, kg/s = 0.83

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 70.90

Latent heat of chemical, J/kg = 288000.00

Specific heat of chemical, J/kg-K = 946.00

Liquid density of chemical, kg/m<sup>3</sup> = 1570.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed

assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Nasal detection

Detection concentration, ppm = 3.50

Ambient temperature, K = 305.60

Boiling temperature, K = 239.10

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1097.20

Building wake factor = 3.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 2.07

Unadjusted horizontal dispersion coef., m = 36.88

Unadjusted vertical dispersion coef., m = 14.80

Horizontal dispersion coefficient, m = 36.94

Vertical dispersion coefficient, m = 14.94

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

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Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	109.98	7.48



1.10	99.43	6.98
1.20	90.77	6.54
1.30	83.29	6.22
1.40	76.78	5.96
1.50	71.12	5.76
1.60	66.21	5.58
1.70	61.92	5.42
1.80	58.09	5.29
1.90	54.70	5.18
2.00	51.68	5.07
2.10	52.32	5.09
2.20	51.04	5.04
2.30	48.71	4.96
2.40	46.57	4.90
2.50	44.62	4.83
2.60	42.84	4.77
2.70	41.17	4.71
2.80	39.63	4.66
2.90	38.18	4.62
3.00	36.84	4.57
3.10	35.58	4.53
3.20	34.41	4.48
3.30	33.29	4.45
3.40	32.23	4.42
3.50	31.23	4.38
3.60	30.26	4.35
3.70	29.36	4.32
3.80	28.51	4.29
3.90	27.70	4.27
4.00	26.94	4.24
4.10	26.22	4.22
4.20	25.53	4.20
4.30	24.89	4.17
4.40	24.27	4.16
4.50	23.68	4.14
4.60	23.12	4.12
4.70	22.60	4.10
4.80	22.09	4.08
4.90	21.60	4.07
5.00	21.14	4.05
5.10	20.69	4.04
5.20	20.27	4.03
5.30	19.86	4.01
5.40	19.47	4.00
5.50	19.09	3.99
5.60	18.73	3.98
5.70	18.38	3.96
5.80	18.05	3.95
5.90	17.72	3.95
6.00	17.41	3.94



time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
918.00	179.20	0.00	0.00	0.00	0.00
919.00	178.20	0.00	0.00	0.00	0.00
920.00	177.20	0.00	0.00	0.00	0.00
921.00	176.20	0.00	0.00	0.00	0.00
922.00	175.20	0.00	0.00	0.00	0.00
923.00	174.20	0.00	0.00	0.00	0.00
924.00	173.20	0.00	0.00	0.00	0.00
925.00	172.20	0.00	0.00	0.00	0.00
926.00	171.20	0.00	0.00	0.00	0.00
927.00	170.20	0.00	0.00	0.00	0.00
928.00	169.20	0.00	0.00	0.00	0.00
929.00	168.20	0.00	0.00	0.00	0.00
930.00	167.20	0.01	0.00	0.01	0.00
931.00	166.20	0.01	0.00	0.01	0.00
932.00	165.20	0.01	0.00	0.01	0.00
933.00	164.20	0.01	0.00	0.01	0.00
934.00	163.20	0.01	0.00	0.01	0.00
935.00	162.20	0.01	0.00	0.01	0.00
936.00	161.20	0.01	0.00	0.01	0.00
937.00	160.20	0.01	0.00	0.01	0.00
938.00	159.20	0.01	0.00	0.01	0.00
939.00	158.20	0.02	0.00	0.02	0.00
940.00	157.20	0.02	0.00	0.02	0.00
941.00	156.20	0.02	0.00	0.02	0.00
942.00	155.20	0.02	0.00	0.02	0.00
943.00	154.20	0.02	0.00	0.02	0.00
944.00	153.20	0.03	0.00	0.03	0.00
945.00	152.20	0.03	0.00	0.03	0.00
946.00	151.20	0.03	0.00	0.03	0.00
947.00	150.20	0.04	0.00	0.04	0.00
948.00	149.20	0.04	0.00	0.04	0.00
949.00	148.20	0.05	0.00	0.05	0.00
950.00	147.20	0.05	0.00	0.05	0.00
951.00	146.20	0.06	0.00	0.06	0.00
952.00	145.20	0.06	0.00	0.06	0.00
953.00	144.20	0.07	0.00	0.07	0.00
954.00	143.20	0.08	0.00	0.08	0.00
955.00	142.20	0.09	0.00	0.09	0.00
956.00	141.20	0.10	0.00	0.10	0.00
957.00	140.20	0.11	0.00	0.11	0.00
958.00	139.20	0.12	0.00	0.12	0.00
959.00	138.20	0.13	0.00	0.13	0.00
960.00	137.20	0.15	0.00	0.15	0.00
961.00	136.20	0.16	0.00	0.16	0.00
962.00	135.20	0.18	0.00	0.18	0.00
963.00	134.20	0.20	0.00	0.20	0.00
964.00	133.20	0.22	0.00	0.22	0.00
965.00	132.20	0.24	0.00	0.24	0.00

966.00	131.20	0.26	0.00	0.26	0.00
967.00	130.20	0.29	0.00	0.29	0.00
968.00	129.20	0.32	0.00	0.32	0.00
969.00	128.20	0.35	0.00	0.35	0.00
970.00	127.20	0.39	0.00	0.39	0.00
971.00	126.20	0.42	0.00	0.42	0.00
972.00	125.20	0.47	0.00	0.47	0.00
973.00	124.20	0.51	0.00	0.51	0.00
974.00	123.20	0.56	0.00	0.56	0.00
975.00	122.20	0.61	0.00	0.61	0.00
976.00	121.20	0.67	0.00	0.67	0.00
977.00	120.20	0.73	0.00	0.73	0.00
978.00	119.20	0.80	0.00	0.80	0.00
979.00	118.20	0.87	0.00	0.87	0.00
980.00	117.20	0.95	0.00	0.95	0.00
981.00	116.20	1.03	0.00	1.03	0.00
982.00	115.20	1.12	0.00	1.12	0.00
983.00	114.20	1.22	0.00	1.22	0.00
984.00	113.20	1.33	0.00	1.33	0.00
985.00	112.20	1.44	0.00	1.44	0.00
986.00	111.20	1.57	0.00	1.57	0.00
987.00	110.20	1.70	0.00	1.70	0.01
988.00	109.20	1.84	0.00	1.84	0.01
989.00	108.20	1.99	0.00	1.99	0.01
990.00	107.20	2.16	0.00	2.16	0.01
991.00	106.20	2.33	0.00	2.33	0.01
992.00	105.20	2.52	0.00	2.52	0.01
993.00	104.20	2.72	0.00	2.72	0.01
994.00	103.20	2.94	0.00	2.94	0.01
995.00	102.20	3.17	0.00	3.17	0.01
996.00	101.20	3.41	0.00	3.41	0.01
997.00	100.20	3.67	0.00	3.67	0.01
998.00	99.20	3.95	0.00	3.95	0.01
999.00	98.20	4.25	0.00	4.25	0.01
1000.00	97.20	4.56	0.00	4.56	0.02
1001.00	96.20	4.90	0.00	4.90	0.02
1002.00	95.20	5.25	0.00	5.25	0.02
1003.00	94.20	5.63	0.00	5.63	0.02
1004.00	93.20	6.03	0.00	6.03	0.02
1005.00	92.20	6.46	0.00	6.46	0.02
1006.00	91.20	6.91	0.00	6.91	0.02
1007.00	90.20	7.38	0.00	7.38	0.03
1008.00	89.20	7.88	0.00	7.88	0.03
1009.00	88.20	8.41	0.00	8.41	0.03
1010.00	87.20	8.97	0.00	8.97	0.03
1011.00	86.20	9.56	0.00	9.56	0.04
1012.00	85.20	10.18	0.00	10.18	0.04
1013.00	84.20	10.83	0.00	10.83	0.04
1014.00	83.20	11.52	0.00	11.52	0.04
1015.00	82.20	12.24	0.00	12.24	0.05
1016.00	81.20	12.99	0.00	12.99	0.05
1017.00	80.20	13.78	0.00	13.78	0.05
1018.00	79.20	14.61	0.00	14.61	0.06

1019.00	78.20	15.48	0.00	15.48	0.06
1020.00	77.20	16.39	0.00	16.39	0.07
1021.00	76.20	17.33	0.00	17.33	0.07
1022.00	75.20	18.32	0.00	18.32	0.08
1023.00	74.20	19.35	0.00	19.35	0.08
1024.00	73.20	20.43	0.00	20.43	0.09
1025.00	72.20	21.55	0.00	21.55	0.09
1026.00	71.20	22.71	0.00	22.71	0.10
1027.00	70.20	23.92	0.00	23.92	0.10
1028.00	69.20	25.17	0.00	25.17	0.11
1029.00	68.20	26.47	0.00	26.47	0.12
1030.00	67.20	27.82	0.00	27.82	0.12
1031.00	66.20	29.21	0.00	29.21	0.13
1032.00	65.20	30.65	0.00	30.65	0.14
1033.00	64.20	32.14	0.00	32.14	0.15
1034.00	63.20	33.68	0.00	33.68	0.16
1035.00	62.20	35.26	0.00	35.26	0.17
1036.00	61.20	36.45	0.00	36.45	0.18
1037.00	60.20	36.60	0.00	36.60	0.18
1038.00	59.20	36.75	0.00	36.75	0.19
1039.00	58.20	36.91	0.00	36.91	0.20
1040.00	57.20	37.05	0.00	37.05	0.21
1041.00	56.20	37.20	0.00	37.20	0.22
1042.00	55.20	37.35	0.00	37.35	0.23
1043.00	54.20	37.49	0.00	37.49	0.24
1044.00	53.20	37.63	0.00	37.63	0.25
1045.00	52.20	37.77	0.00	37.77	0.26
1046.00	51.20	37.90	0.00	37.90	0.27
1047.00	50.20	38.04	0.00	38.04	0.28
1048.00	49.20	38.17	0.00	38.17	0.29
1049.00	48.20	38.30	0.00	38.30	0.30
1050.00	47.20	38.43	0.00	38.43	0.31
1051.00	46.20	38.55	0.00	38.55	0.32
1052.00	45.20	38.68	0.00	38.68	0.33
1053.00	44.20	38.80	0.00	38.80	0.34
1054.00	43.20	38.91	0.00	38.91	0.35
1055.00	42.20	39.03	0.00	39.03	0.36
1056.00	41.20	39.14	0.00	39.14	0.37
1057.00	40.20	39.26	0.00	39.26	0.38
1058.00	39.20	39.36	0.00	39.36	0.39
1059.00	38.20	39.47	0.00	39.47	0.40
1060.00	37.20	39.57	0.00	39.57	0.41
1061.00	36.20	39.68	0.00	39.68	0.42
1062.00	35.20	39.77	0.00	39.77	0.43
1063.00	34.20	39.87	0.00	39.87	0.44
1064.00	33.20	39.96	0.00	39.96	0.45
1065.00	32.20	40.06	0.00	40.06	0.46
1066.00	31.20	40.14	0.00	40.14	0.47
1067.00	30.20	40.23	0.00	40.23	0.48
1068.00	29.20	40.31	0.00	40.31	0.49
1069.00	28.20	40.39	0.00	40.39	0.50
1070.00	27.20	40.47	0.00	40.47	0.52
1071.00	26.20	40.55	0.00	40.55	0.53



1072.00	25.20	40.62	0.00	40.62	0.54
1073.00	24.20	40.69	0.00	40.69	0.55
1074.00	23.20	40.76	0.00	40.76	0.56
1075.00	22.20	40.82	0.00	40.82	0.57
1076.00	21.20	40.88	0.00	40.88	0.58
1077.00	20.20	40.94	0.00	40.94	0.59
1078.00	19.20	41.00	0.00	41.00	0.60
1079.00	18.20	41.05	0.00	41.05	0.61
1080.00	17.20	41.10	0.00	41.10	0.62
1081.00	16.20	41.15	0.00	41.15	0.63
1082.00	15.20	41.20	0.00	41.20	0.64
1083.00	14.20	41.24	0.00	41.24	0.65
1084.00	13.20	41.28	0.00	41.28	0.66
1085.00	12.20	41.31	0.00	41.31	0.67
1086.00	11.20	41.35	0.00	41.35	0.68
1087.00	10.20	41.38	0.00	41.38	0.69
1088.00	9.20	41.41	0.00	41.41	0.70
1089.00	8.20	41.43	0.00	41.43	0.72
1090.00	7.20	41.45	0.00	41.45	0.73
1091.00	6.20	41.47	0.00	41.47	0.74
1092.00	5.20	41.49	0.00	41.49	0.75
1093.00	4.20	41.50	0.00	41.50	0.76
1094.00	3.20	41.51	0.00	41.51	0.77
1095.00	2.20	41.52	0.00	41.52	0.78
1096.00	1.20	41.53	0.00	41.53	0.79
1097.00	0.20	41.53	0.00	41.53	0.80
1098.00	-0.80	41.53	62.73	104.26	0.83
1099.00	-1.80	41.52	154.69	196.21	0.88
1100.00	-2.80	41.52	191.12	232.64	0.94
1101.00	-3.80	41.51	220.49	262.00	1.01
1102.00	-4.80	41.50	245.81	287.31	1.08
1103.00	-5.80	41.48	268.39	309.87	1.16
1104.00	-6.80	41.46	288.75	330.22	1.25
1105.00	-7.80	41.44	272.37	313.81	1.33
1106.00	-8.80	41.42	259.16	300.58	1.41
1107.00	-9.80	41.39	248.22	289.61	1.48
1108.00	-10.80	41.36	238.96	280.32	1.55
1109.00	-11.80	41.33	231.00	272.33	1.62
1110.00	-12.80	41.29	224.05	265.35	1.69
1111.00	-13.80	41.25	217.93	259.18	1.76
1112.00	-14.80	41.21	212.47	253.68	1.83
1113.00	-15.80	41.17	207.56	248.73	1.89
1114.00	-16.80	41.12	203.13	244.25	1.95
1115.00	-17.80	41.07	199.09	240.16	2.01
1116.00	-18.80	41.02	195.39	236.41	2.08
1117.00	-19.80	40.97	191.99	232.96	2.14
1118.00	-20.80	40.91	188.85	229.75	2.19
1119.00	-21.80	40.85	185.93	226.78	2.25
1120.00	-22.80	40.78	183.22	224.00	2.31
1121.00	-23.80	40.72	180.68	221.40	2.37
1122.00	-24.80	40.65	178.30	218.95	2.42
1123.00	-25.80	40.58	176.07	216.65	2.48
1124.00	-26.80	40.50	173.97	214.47	2.54

1125.00	-27.80	40.43	171.99	212.41	2.59
1126.00	-28.80	40.35	170.11	210.46	2.64
1127.00	-29.80	40.26	168.33	208.60	2.70
1128.00	-30.80	40.18	166.64	206.82	2.75
1129.00	-31.80	40.09	165.04	205.13	2.80
1130.00	-32.80	40.00	163.51	203.51	2.86
1131.00	-33.80	39.91	162.05	201.95	2.91
1132.00	-34.80	39.81	160.65	200.46	2.96
1133.00	-35.80	39.72	159.32	199.03	3.01
1134.00	-36.80	39.61	158.04	197.65	3.06
1135.00	-37.80	39.51	156.81	196.32	3.11
1136.00	-38.80	39.41	155.63	195.04	3.16
1137.00	-39.80	39.30	154.50	193.80	3.21
1138.00	-40.80	39.19	153.41	192.60	3.26
1139.00	-41.80	39.08	152.36	191.43	3.31
1140.00	-42.80	38.96	151.35	190.31	3.36
1141.00	-43.80	38.84	150.37	189.21	3.41
1142.00	-44.80	38.72	149.43	188.15	3.45
1143.00	-45.80	38.60	148.52	187.12	3.50
1144.00	-46.80	38.48	147.63	186.11	3.55
1145.00	-47.80	38.35	146.78	185.13	3.60
1146.00	-48.80	38.22	145.95	184.18	3.64
1147.00	-49.80	38.09	145.15	183.24	3.69
1148.00	-50.80	37.96	144.38	182.33	3.74
1149.00	-51.80	37.82	143.62	181.44	3.78
1150.00	-52.80	37.68	142.89	180.57	3.83
1151.00	-53.80	37.54	142.18	179.72	3.87
1152.00	-54.80	37.40	141.49	178.89	3.92
1153.00	-55.80	37.26	140.81	178.07	3.97
1154.00	-56.80	37.11	140.16	177.27	4.01
1155.00	-57.80	36.97	139.52	176.49	4.06
1156.00	-58.80	36.82	138.90	175.72	4.10
1157.00	-59.80	36.66	138.30	174.96	4.14
1158.00	-60.80	36.51	137.71	174.22	4.19
1159.00	-61.80	35.91	137.13	173.04	4.23
1160.00	-62.80	34.31	136.57	170.88	4.28
1161.00	-63.80	32.75	136.03	168.78	4.32
1162.00	-64.80	31.24	135.49	166.73	4.36
1163.00	-65.80	29.78	134.97	164.75	4.40
1164.00	-66.80	28.37	134.46	162.83	4.44
1165.00	-67.80	27.00	133.96	160.96	4.49
1166.00	-68.80	25.69	133.47	159.16	4.53
1167.00	-69.80	24.41	132.99	157.41	4.57
1168.00	-70.80	23.19	132.53	155.71	4.60
1169.00	-71.80	22.01	132.07	154.08	4.64
1170.00	-72.80	20.87	131.62	152.49	4.68
1171.00	-73.80	19.78	131.18	150.96	4.72
1172.00	-74.80	18.73	130.75	149.49	4.76
1173.00	-75.80	17.72	130.33	148.06	4.80
1174.00	-76.80	16.76	129.92	146.68	4.83
1175.00	-77.80	15.84	129.52	145.35	4.87
1176.00	-78.80	14.95	129.12	144.07	4.91
1177.00	-79.80	14.11	128.73	142.84	4.94

1178.00	-80.80	13.30	128.35	141.65	4.98
1179.00	-81.80	12.53	127.98	140.51	5.01
1180.00	-82.80	11.80	127.61	139.41	5.05
1181.00	-83.80	11.10	127.25	138.35	5.08
1182.00	-84.80	10.44	126.89	137.33	5.12
1183.00	-85.80	9.80	126.54	136.35	5.15
1184.00	-86.80	9.20	126.20	135.40	5.18
1185.00	-87.80	8.63	125.87	134.50	5.22
1186.00	-88.80	8.09	125.53	133.63	5.25
1187.00	-89.80	7.58	125.21	132.79	5.28
1188.00	-90.80	7.09	124.89	131.98	5.32
1189.00	-91.80	6.63	124.58	131.21	5.35
1190.00	-92.80	6.20	124.27	130.47	5.38
1191.00	-93.80	5.79	123.96	129.75	5.41
1192.00	-94.80	5.40	123.66	129.07	5.45
1193.00	-95.80	5.04	123.37	128.41	5.48
1194.00	-96.80	4.70	123.08	127.77	5.51
1195.00	-97.80	4.37	122.79	127.17	5.54
1196.00	-98.80	4.07	122.51	126.58	5.57
1197.00	-99.80	3.78	122.24	126.02	5.61
1198.00	-100.80	3.51	121.96	125.48	5.64
1199.00	-101.80	3.26	121.69	124.96	5.67
1200.00	-102.80	3.03	121.43	124.46	5.70
1201.00	-103.80	2.81	121.17	123.98	5.73
1202.00	-104.80	2.60	120.91	123.51	5.76
1203.00	-105.80	2.41	120.66	123.07	5.79
1204.00	-106.80	2.23	120.41	122.64	5.82
1205.00	-107.80	2.06	120.16	122.22	5.85
1206.00	-108.80	1.90	119.92	121.82	5.88
1207.00	-109.80	1.75	119.68	121.44	5.91
1208.00	-110.80	1.62	119.44	121.06	5.94
1209.00	-111.80	1.49	119.21	120.70	5.97
1210.00	-112.80	1.37	118.98	120.36	6.00
1211.00	-113.80	1.26	118.76	120.02	6.03
1212.00	-114.80	1.16	118.53	119.69	6.06
1213.00	-115.80	1.07	118.31	119.38	6.09
1214.00	-116.80	0.98	118.09	119.07	6.12
1215.00	-117.80	0.90	117.88	118.78	6.15
1216.00	-118.80	0.83	117.67	118.49	6.18
1217.00	-119.80	0.76	117.46	118.21	6.21
1218.00	-120.80	0.69	117.25	117.94	6.24
1219.00	-121.80	0.63	117.04	117.68	6.27
1220.00	-122.80	0.58	116.84	117.42	6.29
1221.00	-123.80	0.53	116.64	117.17	6.32
1222.00	-124.80	0.48	116.45	116.93	6.35
1223.00	-125.80	0.44	116.25	116.69	6.38
1224.00	-126.80	0.40	116.06	116.46	6.41
1225.00	-127.80	0.37	115.87	116.23	6.44
1226.00	-128.80	0.33	115.68	116.01	6.47
1227.00	-129.80	0.30	115.49	115.80	6.49
1228.00	-130.80	0.28	115.31	115.59	6.52
1229.00	-131.80	0.25	115.13	115.38	6.55
1230.00	-132.80	0.23	114.95	115.18	6.58

1231.00	-133.80	0.21	114.77	114.98	6.61
1232.00	-134.80	0.19	114.60	114.78	6.64
1233.00	-135.80	0.17	114.42	114.59	6.66
1234.00	-136.80	0.15	114.25	114.40	6.69
1235.00	-137.80	0.14	114.08	114.22	6.72
1236.00	-138.80	0.12	113.91	114.04	6.75
1237.00	-139.80	0.11	113.75	113.86	6.78
1238.00	-140.80	0.10	113.58	113.69	6.80
1239.00	-141.80	0.09	113.42	113.51	6.83
1240.00	-142.80	0.08	113.26	113.34	6.86
1241.00	-143.80	0.07	113.10	113.18	6.89
1242.00	-144.80	0.07	112.94	113.01	6.91
1243.00	-145.80	0.06	112.79	112.85	6.94
1244.00	-146.80	0.05	112.63	112.69	6.97
1245.00	-147.80	0.05	112.48	112.53	7.00
1246.00	-148.80	0.04	112.33	112.37	7.02
1247.00	-149.80	0.04	112.18	112.22	7.05
1248.00	-150.80	0.03	112.03	112.07	7.08
1249.00	-151.80	0.03	111.89	111.92	7.11
1250.00	-152.80	0.03	111.74	111.77	7.13
1251.00	-153.80	0.03	111.60	111.62	7.16
1252.00	-154.80	0.02	111.46	111.48	7.19
1253.00	-155.80	0.02	111.32	111.34	7.22
1254.00	-156.80	0.02	111.18	111.19	7.24
1255.00	-157.80	0.02	111.04	111.05	7.27
1256.00	-158.80	0.01	110.90	110.91	7.30
1257.00	-159.80	0.01	110.77	110.78	7.32
1258.00	-160.80	0.01	110.63	110.64	7.35
1259.00	-161.80	0.01	110.50	110.51	7.38
1260.00	-162.80	0.01	110.37	110.37	7.40
1261.00	-163.80	0.01	110.24	110.24	7.43
1262.00	-164.80	0.01	110.11	110.11	7.46
1263.00	-165.80	0.01	109.98	109.98	7.48
1264.00	-166.80	0.01	109.85	109.86	7.51
1265.00	-167.80	0.00	109.72	109.73	7.54
1266.00	-168.80	0.00	109.60	109.60	7.56
1267.00	-169.80	0.00	109.48	109.48	7.59
1268.00	-170.80	0.00	109.35	109.36	7.62
1269.00	-171.80	0.00	109.23	109.24	7.64
1270.00	-172.80	0.00	109.11	109.11	7.67
1271.00	-173.80	0.00	108.99	108.99	7.70
1272.00	-174.80	0.00	108.87	108.88	7.72
1273.00	-175.80	0.00	108.76	108.76	7.75
1274.00	-176.80	0.00	108.64	108.64	7.78
1275.00	-177.80	0.00	108.52	108.53	7.80
1276.00	-178.80	0.00	108.41	108.41	7.83
1277.00	-179.80	0.00	108.30	108.30	7.85
1278.00	-180.80	0.00	108.18	108.19	7.88
1279.00	-181.80	0.00	108.07	108.07	7.91
1280.00	-182.80	0.00	107.96	107.96	7.93
1281.00	-183.80	0.00	107.85	107.85	7.96
1282.00	-184.80	0.00	107.74	107.74	7.98
1283.00	-185.80	0.00	107.64	107.64	8.01



1284.00	-186.80	0.00	107.53	107.53	8.04
1285.00	-187.80	0.00	107.42	107.42	8.06
1286.00	-188.80	0.00	107.32	107.32	8.09
1287.00	-189.80	0.00	107.21	107.21	8.11
1288.00	-190.80	0.00	107.11	107.11	8.14
1289.00	-191.80	0.00	107.01	107.01	8.16
1290.00	-192.80	0.00	106.90	106.90	8.19
1291.00	-193.80	0.00	106.80	106.80	8.22
1292.00	-194.80	0.00	106.70	106.70	8.24
1293.00	-195.80	0.00	106.60	106.60	8.27
1294.00	-196.80	0.00	106.50	106.50	8.29
1295.00	-197.80	0.00	106.40	106.41	8.32
1296.00	-198.80	0.00	106.31	106.31	8.34
1297.00	-199.80	0.00	106.21	106.21	8.37
1298.00	-200.80	0.00	106.11	106.11	8.39
1299.00	-201.80	0.00	106.02	106.02	8.42
1300.00	-202.80	0.00	105.92	105.92	8.45
1301.00	-203.80	0.00	105.83	105.83	8.47
1302.00	-204.80	0.00	105.74	105.74	8.50
1303.00	-205.80	0.00	105.65	105.65	8.52
1304.00	-206.80	0.00	105.55	105.55	8.55
1305.00	-207.80	0.00	105.46	105.46	8.57
1306.00	-208.80	0.00	105.37	105.37	8.60
1307.00	-209.80	0.00	105.28	105.28	8.62
1308.00	-210.80	0.00	105.19	105.19	8.65
1309.00	-211.80	0.00	105.10	105.10	8.67
1310.00	-212.80	0.00	105.02	105.02	8.70
1311.00	-213.80	0.00	104.93	104.93	8.72
1312.00	-214.80	0.00	104.84	104.84	8.75
1313.00	-215.80	0.00	104.76	104.76	8.77
1314.00	-216.80	0.00	104.67	104.67	8.80
1315.00	-217.80	0.00	104.59	104.59	8.82
1316.00	-218.80	0.00	104.50	104.50	8.85
1317.00	-219.80	0.00	104.42	104.42	8.87
1318.00	-220.80	0.00	104.33	104.33	8.90
1319.00	-221.80	0.00	104.25	104.25	8.92
1320.00	-222.80	0.00	104.17	104.17	8.95
1321.00	-223.80	0.00	104.09	104.09	8.97
1322.00	-224.80	0.00	104.01	104.01	9.00
1323.00	-225.80	0.00	103.93	103.93	9.02
1324.00	-226.80	0.00	103.85	103.85	9.05
1325.00	-227.80	0.00	103.77	103.77	9.07
1326.00	-228.80	0.00	103.69	103.69	9.10
1327.00	-229.80	0.00	103.61	103.61	9.12
1328.00	-230.80	0.00	103.53	103.53	9.14
1329.00	-231.80	0.00	103.45	103.45	9.17
1330.00	-232.80	0.00	103.38	103.38	9.19
1331.00	-233.80	0.00	103.30	103.30	9.22
1332.00	-234.80	0.00	103.23	103.23	9.24
1333.00	-235.80	0.00	103.15	103.15	9.27
1334.00	-236.80	0.00	103.08	103.08	9.29
1335.00	-237.80	0.00	103.00	103.00	9.32
1336.00	-238.80	0.00	102.93	102.93	9.34

1337.00	-239.80	0.00	102.85	102.85	9.36
1338.00	-240.80	0.00	102.78	102.78	9.39
1339.00	-241.80	0.00	102.71	102.71	9.41
1340.00	-242.80	0.00	102.64	102.64	9.44
1341.00	-243.80	0.00	102.56	102.56	9.46
1342.00	-244.80	0.00	102.49	102.49	9.49
1343.00	-245.80	0.00	102.42	102.42	9.51
1344.00	-246.80	0.00	102.35	102.35	9.53
1345.00	-247.80	0.00	102.28	102.28	9.56
1346.00	-248.80	0.00	102.21	102.21	9.58
1347.00	-249.80	0.00	102.14	102.14	9.61
1348.00	-250.80	0.00	102.08	102.08	9.63
1349.00	-251.80	0.00	102.01	102.01	9.65
1350.00	-252.80	0.00	101.94	101.94	9.68
1351.00	-253.80	0.00	101.87	101.87	9.70
1352.00	-254.80	0.00	101.80	101.80	9.73
1353.00	-255.80	0.00	101.74	101.74	9.75
1354.00	-256.80	0.00	101.67	101.67	9.77
1355.00	-257.80	0.00	101.61	101.61	9.80
1356.00	-258.80	0.00	101.54	101.54	9.82
1357.00	-259.80	0.00	101.48	101.48	9.85
1358.00	-260.80	0.00	101.41	101.41	9.87
1359.00	-261.80	0.00	101.35	101.35	9.89
1360.00	-262.80	0.00	101.28	101.28	9.92
1361.00	-263.80	0.00	101.22	101.22	9.94
1362.00	-264.80	0.00	101.16	101.16	9.96
1363.00	-265.80	0.00	101.09	101.09	9.99
1364.00	-266.80	0.00	101.03	101.03	10.01
1365.00	-267.80	0.00	100.97	100.97	10.04
1366.00	-268.80	0.00	100.91	100.91	10.06
1367.00	-269.80	0.00	100.84	100.84	10.08
1368.00	-270.80	0.00	100.78	100.78	10.11
1369.00	-271.80	0.00	100.72	100.72	10.13
1370.00	-272.80	0.00	100.66	100.66	10.15
1371.00	-273.80	0.00	100.60	100.60	10.18
1372.00	-274.80	0.00	100.54	100.54	10.20
1373.00	-275.80	0.00	100.48	100.48	10.22
1374.00	-276.80	0.00	100.42	100.42	10.25
1375.00	-277.80	0.00	100.36	100.36	10.27
1376.00	-278.80	0.00	100.31	100.31	10.30
1377.00	-279.80	0.00	100.25	100.25	10.32
1378.00	-280.80	0.00	100.19	100.19	10.34
1379.00	-281.80	0.00	100.13	100.13	10.37
1380.00	-282.80	0.00	100.08	100.08	10.39
1381.00	-283.80	0.00	100.02	100.02	10.41
1382.00	-284.80	0.00	99.96	99.96	10.44
1383.00	-285.80	0.00	99.91	99.91	10.46

Initial flashing fraction = 0.218

Initial flashing mass = 198.163 kg

Release detected at 1143.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 1097.200 seconds

Wind speed for max CC concentration is 1.000 m/sec

Meander factor at this wind speed is 4.00

Hor. coeff. adjusted for meander = 119.781 m

Maximum CR concentration at 120.0 seconds after detection 7.48 ppm

17.3 Ton Sulfur Dioxide Release at Helper Cooling Tower  
Output file is 173sohct.out

Accident scenario is tank failure

Mass of spill, kg = 15694.60

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Nasal detection

Detection concentration, ppm = 3.00

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 5.05

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.37

Vertical dispersion coefficient, m = 15.14

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	1511.68	35.99



1.10	1264.05	35.92
1.20	916.97	35.12
1.30	734.93	33.58
1.40	638.10	31.90
1.50	572.32	30.54
1.60	528.47	29.05
1.70	492.19	27.73
1.80	460.73	26.56
1.90	434.44	25.40
2.00	410.86	24.35
2.10	414.15	25.10
2.20	418.59	25.72
2.30	421.37	26.42
2.40	423.95	27.09
2.50	426.35	27.74
2.60	429.98	28.26
2.70	432.03	28.86
2.80	435.32	29.32
2.90	437.07	29.87
3.00	438.68	30.40
3.10	441.55	30.80
3.20	428.57	30.81
3.30	416.45	30.67
3.40	403.79	30.64
3.50	393.06	30.49
3.60	381.75	30.44
3.70	372.17	30.27
3.80	362.01	30.19
3.90	353.41	29.98
4.00	345.23	29.74
4.10	336.47	29.53
4.20	329.07	29.15
4.30	321.09	28.65
4.40	314.37	28.01
4.50	307.94	27.40
4.60	301.79	26.82
4.70	295.06	26.33
4.80	289.42	25.80
4.90	284.01	25.28
5.00	278.82	24.79
5.10	273.82	24.31
5.20	268.26	23.92
5.30	263.65	23.48
5.40	258.49	23.12
5.50	254.91	22.65
5.60	250.77	22.26
5.70	246.10	21.94
5.80	242.25	21.57
5.90	238.52	21.21
6.00	234.92	20.87

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
843.00	193.30	0.00	0.00	0.00	0.00
844.00	192.30	0.00	0.00	0.00	0.00
845.00	191.30	0.00	0.00	0.00	0.00
846.00	190.30	0.00	0.00	0.00	0.00
847.00	189.30	0.00	0.00	0.00	0.00
848.00	188.30	0.00	0.00	0.00	0.00
849.00	187.30	0.00	0.00	0.00	0.00
850.00	186.30	0.00	0.00	0.00	0.00
851.00	185.30	0.00	0.00	0.00	0.00
852.00	184.30	0.00	0.00	0.00	0.00
853.00	183.30	0.00	0.00	0.00	0.00
854.00	182.30	0.01	0.00	0.01	0.00
855.00	181.30	0.01	0.00	0.01	0.00
856.00	180.30	0.01	0.00	0.01	0.00
857.00	179.30	0.01	0.00	0.01	0.00
858.00	178.30	0.01	0.00	0.01	0.00
859.00	177.30	0.01	0.00	0.01	0.00
860.00	176.30	0.01	0.00	0.01	0.00
861.00	175.30	0.02	0.00	0.02	0.00
862.00	174.30	0.02	0.00	0.02	0.00
863.00	173.30	0.02	0.00	0.02	0.00
864.00	172.30	0.02	0.00	0.02	0.00
865.00	171.30	0.03	0.00	0.03	0.00
866.00	170.30	0.03	0.00	0.03	0.00
867.00	169.30	0.04	0.00	0.04	0.00
868.00	168.30	0.04	0.00	0.04	0.00
869.00	167.30	0.05	0.00	0.05	0.00
870.00	166.30	0.05	0.00	0.05	0.00
871.00	165.30	0.06	0.00	0.06	0.00
872.00	164.30	0.07	0.00	0.07	0.00
873.00	163.30	0.08	0.00	0.08	0.00
874.00	162.30	0.09	0.00	0.09	0.00
875.00	161.30	0.10	0.00	0.10	0.00
876.00	160.30	0.12	0.00	0.12	0.00
877.00	159.30	0.13	0.00	0.13	0.00
878.00	158.30	0.15	0.00	0.15	0.00
879.00	157.30	0.17	0.00	0.17	0.00
880.00	156.30	0.19	0.00	0.19	0.00
881.00	155.30	0.22	0.00	0.22	0.00
882.00	154.30	0.25	0.00	0.25	0.00
883.00	153.30	0.28	0.00	0.28	0.00
884.00	152.30	0.32	0.00	0.32	0.00
885.00	151.30	0.36	0.00	0.36	0.00
886.00	150.30	0.41	0.00	0.41	0.00
887.00	149.30	0.46	0.00	0.46	0.00
888.00	148.30	0.52	0.00	0.52	0.00
889.00	147.30	0.58	0.00	0.58	0.00
890.00	146.30	0.65	0.00	0.65	0.00

891.00	145.30	0.73	0.00	0.73	0.00
892.00	144.30	0.82	0.00	0.82	0.00
893.00	143.30	0.92	0.00	0.92	0.00
894.00	142.30	1.04	0.00	1.04	0.00
895.00	141.30	1.16	0.00	1.16	0.00
896.00	140.30	1.30	0.00	1.30	0.00
897.00	139.30	1.45	0.00	1.45	0.00
898.00	138.30	1.62	0.00	1.62	0.00
899.00	137.30	1.81	0.00	1.81	0.00
900.00	136.30	2.02	0.00	2.02	0.00
901.00	135.30	2.25	0.00	2.25	0.01
902.00	134.30	2.51	0.00	2.51	0.01
903.00	133.30	2.79	0.00	2.79	0.01
904.00	132.30	3.11	0.00	3.11	0.01
905.00	131.30	3.45	0.00	3.45	0.01
906.00	130.30	3.83	0.00	3.83	0.01
907.00	129.30	4.25	0.00	4.25	0.01
908.00	128.30	4.71	0.00	4.71	0.01
909.00	127.30	5.22	0.00	5.22	0.01
910.00	126.30	5.78	0.00	5.78	0.01
911.00	125.30	6.39	0.00	6.39	0.02
912.00	124.30	7.06	0.00	7.06	0.02
913.00	123.30	7.79	0.00	7.79	0.02
914.00	122.30	8.60	0.00	8.60	0.02
915.00	121.30	9.48	0.00	9.48	0.02
916.00	120.30	10.44	0.00	10.44	0.03
917.00	119.30	11.49	0.00	11.49	0.03
918.00	118.30	12.63	0.00	12.63	0.03
919.00	117.30	13.88	0.00	13.88	0.04
920.00	116.30	15.24	0.00	15.24	0.04
921.00	115.30	16.72	0.00	16.72	0.05
922.00	114.30	18.32	0.00	18.32	0.05
923.00	113.30	20.07	0.00	20.07	0.06
924.00	112.30	21.96	0.00	21.96	0.06
925.00	111.30	24.01	0.00	24.01	0.07
926.00	110.30	26.24	0.00	26.24	0.07
927.00	109.30	28.65	0.00	28.65	0.08
928.00	108.30	31.25	0.00	31.25	0.09
929.00	107.30	34.06	0.00	34.06	0.10
930.00	106.30	37.10	0.00	37.10	0.11
931.00	105.30	40.37	0.00	40.37	0.12
932.00	104.30	43.90	0.00	43.90	0.13
933.00	103.30	47.70	0.00	47.70	0.14
934.00	102.30	51.79	0.00	51.79	0.16
935.00	101.30	56.18	0.00	56.18	0.17
936.00	100.30	60.89	0.00	60.89	0.19
937.00	99.30	65.95	0.00	65.95	0.20
938.00	98.30	71.37	0.00	71.37	0.22
939.00	97.30	77.17	0.00	77.17	0.24
940.00	96.30	83.38	0.00	83.38	0.26
941.00	95.30	90.02	0.00	90.02	0.29
942.00	94.30	97.11	0.00	97.11	0.31
943.00	93.30	104.67	0.00	104.67	0.34



944.00	92.30	112.73	0.00	112.73	0.37
945.00	91.30	121.31	0.00	121.31	0.40
946.00	90.30	130.45	0.00	130.45	0.43
947.00	89.30	140.16	0.00	140.16	0.47
948.00	88.30	150.47	0.00	150.47	0.51
949.00	87.30	161.41	0.00	161.41	0.55
950.00	86.30	173.01	0.00	173.01	0.60
951.00	85.30	185.29	0.00	185.29	0.64
952.00	84.30	198.29	0.00	198.29	0.70
953.00	83.30	212.03	0.00	212.03	0.75
954.00	82.30	226.54	0.00	226.54	0.81
955.00	81.30	241.85	0.00	241.85	0.87
956.00	80.30	257.99	0.00	257.99	0.94
957.00	79.30	274.99	0.00	274.99	1.01
958.00	78.30	292.87	0.00	292.87	1.09
959.00	77.30	311.66	0.00	311.66	1.17
960.00	76.30	331.40	0.00	331.40	1.25
961.00	75.30	352.10	0.00	352.10	1.34
962.00	74.30	373.80	0.00	373.80	1.44
963.00	73.30	396.52	0.00	396.52	1.54
964.00	72.30	420.28	0.00	420.28	1.65
965.00	71.30	445.11	0.00	445.11	1.77
966.00	70.30	471.03	0.00	471.03	1.89
967.00	69.30	498.06	0.00	498.06	2.02
968.00	68.30	516.75	0.00	516.75	2.15
969.00	67.30	519.27	0.00	519.27	2.29
970.00	66.30	521.77	0.00	521.77	2.42
971.00	65.30	524.25	0.00	524.25	2.56
972.00	64.30	526.70	0.00	526.70	2.70
973.00	63.30	529.12	0.00	529.12	2.83
974.00	62.30	531.52	0.00	531.52	2.97
975.00	61.30	533.88	0.00	533.88	3.11
976.00	60.30	536.22	0.00	536.22	3.25
977.00	59.30	538.53	0.00	538.53	3.39
978.00	58.30	540.82	0.00	540.82	3.53
979.00	57.30	543.07	0.00	543.07	3.67
980.00	56.30	545.29	0.00	545.29	3.81
981.00	55.30	547.49	0.00	547.49	3.95
982.00	54.30	549.65	0.00	549.65	4.09
983.00	53.30	551.78	0.00	551.78	4.23
984.00	52.30	553.88	0.00	553.88	4.38
985.00	51.30	555.95	0.00	555.95	4.52
986.00	50.30	557.98	0.00	557.98	4.67
987.00	49.30	559.98	0.00	559.98	4.81
988.00	48.30	561.95	0.00	561.95	4.96
989.00	47.30	563.89	0.00	563.89	5.10
990.00	46.30	565.79	0.00	565.79	5.25
991.00	45.30	567.66	0.00	567.66	5.39
992.00	44.30	569.49	0.00	569.49	5.54
993.00	43.30	571.29	0.00	571.29	5.69
994.00	42.30	573.05	0.00	573.05	5.83
995.00	41.30	574.77	0.00	574.77	5.98
996.00	40.30	576.46	0.00	576.46	6.13

997.00	39.30	578.12	0.00	578.12	6.28
998.00	38.30	579.73	0.00	579.73	6.43
999.00	37.30	581.31	0.00	581.31	6.58
1000.00	36.30	582.85	0.00	582.85	6.73
1001.00	35.30	584.35	0.00	584.35	6.88
1002.00	34.30	585.82	0.00	585.82	7.03
1003.00	33.30	587.24	0.00	587.24	7.18
1004.00	32.30	588.63	0.00	588.63	7.33
1005.00	31.30	589.98	0.00	589.98	7.48
1006.00	30.30	591.29	0.00	591.29	7.64
1007.00	29.30	592.56	0.00	592.56	7.79
1008.00	28.30	593.79	0.00	593.79	7.94
1009.00	27.30	594.97	0.00	594.97	8.09
1010.00	26.30	596.12	0.00	596.12	8.25
1011.00	25.30	597.23	0.00	597.23	8.40
1012.00	24.30	598.30	0.00	598.30	8.55
1013.00	23.30	599.32	0.00	599.32	8.71
1014.00	22.30	600.30	0.00	600.30	8.86
1015.00	21.30	601.25	0.00	601.25	9.02
1016.00	20.30	602.15	0.00	602.15	9.17
1017.00	19.30	603.00	0.00	603.00	9.32
1018.00	18.30	603.82	0.00	603.82	9.48
1019.00	17.30	604.59	0.00	604.59	9.63
1020.00	16.30	605.33	0.00	605.33	9.79
1021.00	15.30	606.01	0.00	606.01	9.94
1022.00	14.30	606.66	0.00	606.66	10.10
1023.00	13.30	607.26	0.00	607.26	10.26
1024.00	12.30	607.82	0.00	607.82	10.41
1025.00	11.30	608.34	0.00	608.34	10.57
1026.00	10.30	608.81	0.00	608.81	10.72
1027.00	9.30	609.24	0.00	609.24	10.88
1028.00	8.30	609.62	0.00	609.62	11.03
1029.00	7.30	609.97	0.00	609.97	11.19
1030.00	6.30	610.27	0.00	610.27	11.35
1031.00	5.30	610.52	0.00	610.52	11.50
1032.00	4.30	610.73	0.00	610.73	11.66
1033.00	3.30	610.90	0.00	610.90	11.81
1034.00	2.30	611.02	0.00	611.02	11.97
1035.00	1.30	611.10	0.00	611.10	12.13
1036.00	0.30	611.14	0.00	611.14	12.28
1037.00	-0.70	611.13	41.36	652.49	12.45
1038.00	-1.70	611.07	258.79	869.87	12.67
1039.00	-2.70	610.98	342.19	953.17	12.92
1040.00	-3.70	610.84	411.91	1022.75	13.18
1041.00	-4.70	610.65	473.25	1083.90	13.46
1042.00	-5.70	610.42	528.86	1139.29	13.75
1043.00	-6.70	610.15	580.26	1190.41	14.06
1044.00	-7.70	609.84	628.37	1238.20	14.38
1045.00	-8.70	609.48	673.83	1283.30	14.71
1046.00	-9.70	609.07	717.09	1326.17	15.05
1047.00	-10.70	608.63	758.50	1367.12	15.40
1048.00	-11.70	608.14	798.29	1406.43	15.76
1049.00	-12.70	607.60	836.68	1444.28	16.13

1050.00	-13.70	607.03	873.81	1480.84	16.51
1051.00	-14.70	606.41	909.84	1516.24	16.90
1052.00	-15.70	605.74	944.86	1550.60	17.30
1053.00	-16.70	605.04	978.96	1583.99	17.71
1054.00	-17.70	604.29	1012.22	1616.51	18.13
1055.00	-18.70	603.50	1044.71	1648.21	18.55
1056.00	-19.70	602.67	1076.48	1679.15	18.98
1057.00	-20.70	601.79	1107.59	1709.39	19.42
1058.00	-21.70	600.87	1138.08	1738.96	19.87
1059.00	-22.70	599.92	1167.99	1767.91	20.33
1060.00	-23.70	598.92	1197.35	1796.27	20.79
1061.00	-24.70	597.87	1226.19	1824.07	21.26
1062.00	-25.70	596.79	1254.55	1851.34	21.73
1063.00	-26.70	595.67	1282.44	1878.11	22.22
1064.00	-27.70	594.50	1309.88	1904.39	22.71
1065.00	-28.70	593.30	1296.97	1890.27	23.19
1066.00	-29.70	592.05	1278.44	1870.49	23.68
1067.00	-30.70	590.77	1260.84	1851.61	24.15
1068.00	-31.70	589.44	1244.10	1833.54	24.62
1069.00	-32.70	588.08	1228.15	1816.23	25.09
1070.00	-33.70	586.68	1212.93	1799.61	25.55
1071.00	-34.70	585.24	1198.39	1783.63	26.01
1072.00	-35.70	583.76	1184.48	1768.23	26.46
1073.00	-36.70	582.24	1171.15	1753.39	26.91
1074.00	-37.70	580.68	1158.36	1739.04	27.36
1075.00	-38.70	579.09	1146.08	1725.17	27.80
1076.00	-39.70	577.46	1134.28	1711.74	28.24
1077.00	-40.70	575.79	1122.92	1698.72	28.67
1078.00	-41.70	574.09	1111.98	1686.07	29.10
1079.00	-42.70	572.35	1101.44	1673.79	29.53
1080.00	-43.70	570.57	1091.26	1661.83	29.96
1081.00	-44.70	568.76	1081.44	1650.20	30.38
1082.00	-45.70	566.92	1071.94	1638.85	30.80
1083.00	-46.70	565.03	1062.75	1627.79	31.21
1084.00	-47.70	563.12	1053.86	1616.98	31.62
1085.00	-48.70	561.17	1045.25	1606.42	32.03
1086.00	-49.70	559.19	1036.90	1596.09	32.44
1087.00	-50.70	557.17	1028.81	1585.98	32.85
1088.00	-51.70	555.12	1020.95	1576.07	33.25
1089.00	-52.70	553.04	1013.32	1566.36	33.65
1090.00	-53.70	550.93	1005.91	1556.84	34.04
1091.00	-54.70	548.79	998.70	1547.49	34.44
1092.00	-55.70	546.61	991.70	1538.31	34.83
1093.00	-56.70	544.41	984.88	1529.29	35.22
1094.00	-57.70	542.17	978.24	1520.41	35.60
1095.00	-58.70	539.91	971.77	1511.68	35.99
1096.00	-59.70	537.61	965.47	1503.09	36.37
1097.00	-60.70	535.29	959.33	1494.62	36.75
1098.00	-61.70	532.94	953.34	1486.28	37.13
1099.00	-62.70	530.56	947.49	1478.05	37.50
1100.00	-63.70	528.15	941.79	1469.94	37.88
1101.00	-64.70	525.72	936.22	1461.94	38.25
1102.00	-65.70	523.26	930.77	1454.03	38.61

1103.00	-66.70	520.78	925.46	1446.23	38.98
1104.00	-67.70	518.26	920.26	1438.52	39.35
1105.00	-68.70	514.82	915.17	1430.00	39.71
1106.00	-69.70	487.11	910.20	1397.31	40.06
1107.00	-70.70	460.53	905.33	1365.86	40.41
1108.00	-71.70	435.05	900.57	1335.62	40.74
1109.00	-72.70	410.65	895.91	1306.56	41.07
1110.00	-73.70	387.31	891.34	1278.65	41.39
1111.00	-74.70	365.00	886.87	1251.87	41.71
1112.00	-75.70	343.70	882.48	1226.18	42.02
1113.00	-76.70	323.39	878.19	1201.57	42.32
1114.00	-77.70	304.03	873.97	1178.01	42.62
1115.00	-78.70	285.61	869.84	1155.45	42.90
1116.00	-79.70	268.08	865.79	1133.87	43.19
1117.00	-80.70	251.43	861.81	1113.24	43.47
1118.00	-81.70	235.63	857.91	1093.54	43.74
1119.00	-82.70	220.64	854.07	1074.72	44.01
1120.00	-83.70	206.45	850.31	1056.76	44.27
1121.00	-84.70	193.01	846.62	1039.62	44.53
1122.00	-85.70	180.30	842.99	1023.28	44.79
1123.00	-86.70	168.29	839.42	1007.71	45.04
1124.00	-87.70	156.96	835.92	992.88	45.28
1125.00	-88.70	146.27	832.47	978.74	45.53
1126.00	-89.70	136.20	829.09	965.29	45.77
1127.00	-90.70	126.73	825.76	952.48	46.00
1128.00	-91.70	117.82	822.48	940.30	46.24
1129.00	-92.70	109.44	819.26	928.71	46.46
1130.00	-93.70	101.59	816.09	917.68	46.69
1131.00	-94.70	94.22	812.97	907.19	46.92
1132.00	-95.70	87.31	809.91	897.22	47.14
1133.00	-96.70	80.85	806.88	887.73	47.36
1134.00	-97.70	74.80	803.91	878.71	47.57
1135.00	-98.70	69.16	800.98	870.14	47.79
1136.00	-99.70	63.88	798.10	861.98	48.00
1137.00	-100.70	58.97	795.26	854.22	48.21
1138.00	-101.70	54.38	792.46	846.84	48.42
1139.00	-102.70	50.12	789.70	839.82	48.62
1140.00	-103.70	46.15	786.99	833.13	48.83
1141.00	-104.70	42.46	784.31	826.77	49.03
1142.00	-105.70	39.03	781.67	820.70	49.23
1143.00	-106.70	35.86	779.07	814.92	49.43
1144.00	-107.70	32.91	776.50	809.41	49.63
1145.00	-108.70	30.18	773.97	804.16	49.82
1146.00	-109.70	27.66	771.48	799.14	50.02
1147.00	-110.70	25.33	769.02	794.35	50.21
1148.00	-111.70	23.17	766.59	789.77	50.40
1149.00	-112.70	21.19	764.20	785.38	50.60
1150.00	-113.70	19.35	761.83	781.19	50.79
1151.00	-114.70	17.66	759.50	777.17	50.97
1152.00	-115.70	16.11	757.20	773.31	51.16
1153.00	-116.70	14.68	754.93	769.61	51.35
1154.00	-117.70	13.37	752.69	766.06	51.54
1155.00	-118.70	12.16	750.48	762.64	51.72

1156.00	-119.70	11.06	748.29	759.35	51.91
1157.00	-120.70	10.04	746.13	756.18	52.09
1158.00	-121.70	9.12	744.00	753.12	52.27
1159.00	-122.70	8.27	741.90	750.16	52.45
1160.00	-123.70	7.49	739.82	747.31	52.63
1161.00	-124.70	6.78	737.76	744.55	52.81
1162.00	-125.70	6.14	735.73	741.87	52.99
1163.00	-126.70	5.55	733.73	739.28	53.17
1164.00	-127.70	5.01	731.75	736.76	53.35
1165.00	-128.70	4.52	729.79	734.31	53.53
1166.00	-129.70	4.08	727.85	731.93	53.70
1167.00	-130.70	3.68	725.94	729.62	53.88
1168.00	-131.70	3.31	724.05	727.36	54.05
1169.00	-132.70	2.98	722.18	725.16	54.23
1170.00	-133.70	2.68	720.33	723.01	54.40
1171.00	-134.70	2.41	718.50	720.91	54.58
1172.00	-135.70	2.16	716.70	718.85	54.75
1173.00	-136.70	1.94	714.91	716.84	54.92
1174.00	-137.70	1.73	713.14	714.87	55.09
1175.00	-138.70	1.55	711.39	712.94	55.27
1176.00	-139.70	1.39	709.66	711.05	55.44
1177.00	-140.70	1.24	707.95	709.19	55.61
1178.00	-141.70	1.11	706.26	707.37	55.78
1179.00	-142.70	0.99	704.58	705.57	55.94
1180.00	-143.70	0.88	702.93	703.81	56.11
1181.00	-144.70	0.79	701.29	702.07	56.28
1182.00	-145.70	0.70	699.66	700.36	56.45
1183.00	-146.70	0.62	698.06	698.68	56.62
1184.00	-147.70	0.55	696.47	697.02	56.78
1185.00	-148.70	0.49	694.89	695.39	56.95
1186.00	-149.70	0.44	693.33	693.77	57.11
1187.00	-150.70	0.39	691.79	692.18	57.28
1188.00	-151.70	0.34	690.27	690.61	57.45
1189.00	-152.70	0.30	688.75	689.06	57.61
1190.00	-153.70	0.27	687.26	687.53	57.77
1191.00	-154.70	0.24	685.77	686.01	57.94
1192.00	-155.70	0.21	684.31	684.52	58.10
1193.00	-156.70	0.19	682.85	683.04	58.26
1194.00	-157.70	0.16	681.41	681.58	58.43
1195.00	-158.70	0.14	679.99	680.13	58.59
1196.00	-159.70	0.13	678.57	678.70	58.75
1197.00	-160.70	0.11	677.17	677.29	58.91
1198.00	-161.70	0.10	675.79	675.89	59.07
1199.00	-162.70	0.09	674.41	674.50	59.23
1200.00	-163.70	0.08	673.05	673.13	59.39
1201.00	-164.70	0.07	671.70	671.77	59.55
1202.00	-165.70	0.06	670.37	670.43	59.71
1203.00	-166.70	0.05	669.04	669.10	59.87
1204.00	-167.70	0.04	667.73	667.78	60.03
1205.00	-168.70	0.04	666.43	666.47	60.18
1206.00	-169.70	0.03	665.14	665.18	60.34
1207.00	-170.70	0.03	663.87	663.89	60.50
1208.00	-171.70	0.03	662.60	662.62	60.65



1209.00	-172.70	0.02	661.34	661.37	60.81
1210.00	-173.70	0.02	660.10	660.12	60.97
1211.00	-174.70	0.02	658.87	658.88	61.12
1212.00	-175.70	0.01	657.64	657.66	61.28
1213.00	-176.70	0.01	656.43	656.44	61.43
1214.00	-177.70	0.01	655.23	655.24	61.59
1215.00	-178.70	0.01	654.04	654.05	61.74

Initial flashing fraction = 0.165

Initial flashing mass = 2588.410 kg

Release detected at 975.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 1036.300 seconds

Wind speed for max CC concentration is 1.000 m/sec

Meander factor at this wind speed is 4.00

Hor. coeff. adjusted for meander = 117.909 m

Maximum CR concentration at 120.0 seconds after detection 35.99 ppm

50 Ton Sulfur Dioxide Release at Helper Cooling Tower  
Output file is 50so2hct.out

Accident scenario is tank failure

Mass of spill, kg = 45360.00

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Nasal detection

Detection concentration, ppm = 3.00

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 7.19

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.74

Vertical dispersion coefficient, m = 15.98

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	4268.43	70.02

1.10	4088.72	73.74
1.20	3677.96	75.79
1.30	2679.29	75.92
1.40	2087.59	73.89
1.50	1751.27	71.48
1.60	1566.49	68.32
1.70	1437.16	65.45
1.80	1336.41	62.87
1.90	1256.71	60.23
2.00	1186.37	57.85
2.10	1190.03	60.12
2.20	1193.11	62.33
2.30	1195.75	64.48
2.40	1197.99	66.56
2.50	1204.23	68.27
2.60	1209.99	69.93
2.70	1215.30	71.53
2.80	1220.19	73.05
2.90	1224.69	74.51
3.00	1228.83	75.92
3.10	1223.49	77.01
3.20	1183.76	77.16
3.30	1150.23	76.99
3.40	1114.99	77.09
3.50	1085.29	76.88
3.60	1050.46	77.15
3.70	1027.33	76.60
3.80	995.90	76.72
3.90	972.22	76.26
4.00	949.71	75.68
4.10	925.41	75.16
4.20	905.05	74.07
4.30	882.92	72.62
4.40	864.42	71.00
4.50	846.73	69.45
4.60	827.31	68.17
4.70	811.14	66.75
4.80	793.28	65.59
4.90	778.44	64.28
5.00	764.18	63.02
5.10	750.46	61.81
5.20	737.27	60.65
5.30	722.47	59.71
5.40	710.27	58.63
5.50	698.50	57.59
5.60	687.14	56.58
5.70	674.25	55.78
5.80	663.69	54.84
5.90	653.48	53.93
6.00	641.80	53.21

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
261.00	201.10	0.00	0.00	0.00	0.00
262.00	197.90	0.00	0.00	0.00	0.00
263.00	194.70	0.00	0.00	0.00	0.00
264.00	191.50	0.01	0.00	0.01	0.00
265.00	188.30	0.01	0.00	0.01	0.00
266.00	185.10	0.01	0.00	0.01	0.00
267.00	181.90	0.02	0.00	0.02	0.00
268.00	178.70	0.03	0.00	0.03	0.00
269.00	175.50	0.05	0.00	0.05	0.00
270.00	172.30	0.08	0.00	0.08	0.00
271.00	169.10	0.13	0.00	0.13	0.00
272.00	165.90	0.19	0.00	0.19	0.00
273.00	162.70	0.29	0.00	0.29	0.00
274.00	159.50	0.43	0.00	0.43	0.00
275.00	156.30	0.64	0.00	0.64	0.00
276.00	153.10	0.94	0.00	0.94	0.00
277.00	149.90	1.38	0.00	1.38	0.00
278.00	146.70	2.00	0.00	2.00	0.00
279.00	143.50	2.87	0.00	2.87	0.00
280.00	140.30	4.10	0.00	4.10	0.00
281.00	137.10	5.80	0.00	5.80	0.00
282.00	133.90	8.14	0.00	8.14	0.01
283.00	130.70	11.34	0.00	11.34	0.01
284.00	127.50	15.68	0.00	15.68	0.01
285.00	124.30	21.49	0.00	21.49	0.02
286.00	121.10	29.23	0.00	29.23	0.03
287.00	117.90	39.43	0.00	39.43	0.04
288.00	114.70	52.77	0.00	52.77	0.05
289.00	111.50	70.06	0.00	70.06	0.07
290.00	108.30	92.27	0.00	92.27	0.09
291.00	105.10	120.55	0.00	120.55	0.12
292.00	101.90	156.24	0.00	156.24	0.17
293.00	98.70	200.88	0.00	200.88	0.22
294.00	95.50	256.22	0.00	256.22	0.28
295.00	92.30	324.19	0.00	324.19	0.37
296.00	89.10	406.91	0.00	406.91	0.47
297.00	85.90	506.66	0.00	506.66	0.61
298.00	82.70	625.83	0.00	625.83	0.77
299.00	79.50	766.86	0.00	766.86	0.97
300.00	76.30	932.15	0.00	932.15	1.21
301.00	73.10	1124.03	0.00	1124.03	1.50
302.00	69.90	1344.58	0.00	1344.58	1.85
303.00	66.70	1595.57	0.00	1595.57	2.27
304.00	63.50	1878.28	0.00	1878.28	2.76
305.00	60.30	2193.42	0.00	2193.42	3.33
306.00	57.10	2540.98	0.00	2540.98	3.99
307.00	53.90	2920.10	0.00	2920.10	4.75
308.00	50.70	3329.00	0.00	3329.00	5.61

309.00	47.50	3764.83	0.00	3764.83	6.59
310.00	44.30	4026.96	0.00	4026.96	7.64
311.00	41.10	4146.15	0.00	4146.15	8.71
312.00	37.90	4259.54	0.00	4259.54	9.82
313.00	34.70	4366.47	0.00	4366.47	10.95
314.00	31.50	4466.32	0.00	4466.32	12.11
315.00	28.30	4558.47	0.00	4558.47	13.30
316.00	25.10	4642.37	0.00	4642.37	14.50
317.00	21.90	4717.49	0.00	4717.49	15.73
318.00	18.70	4783.36	0.00	4783.36	16.97
319.00	15.50	4839.56	0.00	4839.56	18.22
320.00	12.30	4885.73	0.00	4885.73	19.49
321.00	9.10	4921.57	0.00	4921.57	20.77
322.00	5.90	4946.85	0.00	4946.85	22.05
323.00	2.70	4961.40	0.00	4961.40	23.33
324.00	-0.50	4965.13	41.31	5006.44	24.63
325.00	-3.70	4958.01	223.25	5181.26	25.97
326.00	-6.90	4940.09	292.06	5232.15	27.33
327.00	-10.10	4911.49	350.56	5262.05	28.69
328.00	-13.30	4872.40	402.45	5274.85	30.06
329.00	-16.50	4823.06	449.76	5272.82	31.42
330.00	-19.70	4763.80	493.67	5257.47	32.78
331.00	-22.90	4694.99	534.92	5229.91	34.13
332.00	-26.10	4617.07	574.02	5191.10	35.48
333.00	-29.30	4530.54	611.34	5141.88	36.80
334.00	-32.50	4435.91	647.15	5083.07	38.12
335.00	-35.70	4333.79	681.65	5015.44	39.41
336.00	-38.90	4224.76	715.01	4939.78	40.69
337.00	-42.10	4109.49	747.36	4856.85	41.94
338.00	-45.30	3988.64	778.81	4767.44	43.17
339.00	-48.50	3625.95	809.44	4435.39	44.32
340.00	-51.70	3198.17	839.33	4037.50	45.36
341.00	-54.90	2798.33	868.54	3666.87	46.30
342.00	-58.10	2428.92	897.14	3326.05	47.15
343.00	-61.30	2091.44	925.15	3016.59	47.93
344.00	-64.50	1786.47	952.64	2739.10	48.63
345.00	-67.70	1513.78	979.63	2493.41	49.26
346.00	-70.90	1272.47	1006.15	2278.62	49.84
347.00	-74.10	1061.08	1032.24	2093.32	50.37
348.00	-77.30	877.75	1057.92	1935.66	50.87
349.00	-80.50	720.29	1083.20	1803.49	51.32
350.00	-83.70	586.36	1108.12	1694.48	51.75
351.00	-86.90	473.52	1132.69	1606.21	52.15
352.00	-90.10	379.34	1156.93	1536.27	52.54
353.00	-93.30	301.46	1180.86	1482.32	52.91
354.00	-96.50	237.66	1204.47	1442.14	53.27
355.00	-99.70	185.87	1227.80	1413.67	53.63
356.00	-102.90	144.20	1250.86	1395.06	53.98
357.00	-106.10	110.98	1273.64	1384.62	54.32
358.00	-109.30	84.73	1296.17	1380.90	54.67
359.00	-112.50	64.17	1318.45	1382.62	55.01
360.00	-115.70	48.22	1340.49	1388.71	55.36
361.00	-118.90	35.94	1362.31	1398.24	55.71

362.00	-122.10	26.57	1383.89	1410.47	56.06
363.00	-125.30	19.49	1405.27	1424.76	56.42
364.00	-128.50	14.18	1426.43	1440.61	56.78
365.00	-131.70	10.24	1447.39	1457.63	57.14
366.00	-134.90	7.33	1468.15	1475.48	57.51
367.00	-138.10	5.21	1488.72	1493.93	57.89
368.00	-141.30	3.67	1509.11	1512.78	58.27
369.00	-144.50	2.56	1529.31	1531.87	58.65
370.00	-147.70	1.78	1549.33	1551.11	59.04
371.00	-150.90	1.22	1552.71	1553.93	59.43
372.00	-154.10	0.83	1540.55	1541.39	59.81
373.00	-157.30	0.57	1528.77	1529.33	60.20
374.00	-160.50	0.38	1517.34	1517.72	60.58
375.00	-163.70	0.25	1506.25	1506.51	60.95
376.00	-166.90	0.17	1495.49	1495.65	61.33
377.00	-170.10	0.11	1485.03	1485.14	61.70
378.00	-173.30	0.07	1474.86	1474.93	62.06
379.00	-176.50	0.05	1464.97	1465.01	62.43
380.00	-179.70	0.03	1455.34	1455.37	62.79
381.00	-182.90	0.02	1445.97	1445.99	63.15
382.00	-186.10	0.01	1436.85	1436.86	63.51
383.00	-189.30	0.01	1427.95	1427.96	63.86
384.00	-192.50	0.00	1419.28	1419.29	64.22
385.00	-195.70	0.00	1410.83	1410.83	64.57
386.00	-198.90	0.00	1402.58	1402.58	64.92
387.00	-202.10	0.00	1394.52	1394.52	65.26
388.00	-205.30	0.00	1386.66	1386.66	65.61
389.00	-208.50	0.00	1378.98	1378.98	65.95
390.00	-211.70	0.00	1371.47	1371.47	66.29
391.00	-214.90	0.00	1364.13	1364.13	66.63
392.00	-218.10	0.00	1356.96	1356.96	66.96
393.00	-221.30	0.00	1349.94	1349.94	67.30
394.00	-224.50	0.00	1343.07	1343.07	67.63
395.00	-227.70	0.00	1336.35	1336.35	67.96
396.00	-230.90	0.00	1329.77	1329.77	68.29
397.00	-234.10	0.00	1323.32	1323.32	68.61
398.00	-237.30	0.00	1317.01	1317.01	68.94
399.00	-240.50	0.00	1310.82	1310.82	69.26
400.00	-243.70	0.00	1304.75	1304.75	69.58
401.00	-246.90	0.00	1298.81	1298.81	69.90
402.00	-250.10	0.00	1292.97	1292.97	70.22
403.00	-253.30	0.00	1287.25	1287.25	70.54
404.00	-256.50	0.00	1281.64	1281.64	70.85
405.00	-259.70	0.00	1276.13	1276.13	71.17
406.00	-262.90	0.00	1270.72	1270.72	71.48
407.00	-266.10	0.00	1265.41	1265.41	71.79
408.00	-269.30	0.00	1260.20	1260.20	72.10
409.00	-272.50	0.00	1255.07	1255.07	72.41
410.00	-275.70	0.00	1250.04	1250.04	72.71
411.00	-278.90	0.00	1245.09	1245.09	73.02
412.00	-282.10	0.00	1240.23	1240.23	73.32
413.00	-285.30	0.00	1235.45	1235.45	73.62
414.00	-288.50	0.00	1230.75	1230.75	73.93

415.00	-291.70	0.00	1226.13	1226.13	74.23
416.00	-294.90	0.00	1221.59	1221.59	74.52
417.00	-298.10	0.00	1217.11	1217.11	74.82
418.00	-301.30	0.00	1212.71	1212.71	75.12
419.00	-304.50	0.00	1208.38	1208.38	75.41
420.00	-307.70	0.00	1204.12	1204.12	75.71
421.00	-310.90	0.00	1199.92	1199.92	76.00
422.00	-314.10	0.00	1195.79	1195.79	76.29
423.00	-317.30	0.00	1191.71	1191.71	76.58
424.00	-320.50	0.00	1187.71	1187.71	76.87
425.00	-323.70	0.00	1183.76	1183.76	77.16
426.00	-326.90	0.00	1179.87	1179.87	77.45
427.00	-330.10	0.00	1176.03	1176.03	77.73
428.00	-333.30	0.00	1172.25	1172.25	78.02
429.00	-336.50	0.00	1168.53	1168.53	78.30
430.00	-339.70	0.00	1164.85	1164.85	78.58
431.00	-342.90	0.00	1161.23	1161.23	78.87
432.00	-346.10	0.00	1157.66	1157.66	79.15
433.00	-349.30	0.00	1154.14	1154.14	79.43
434.00	-352.50	0.00	1150.67	1150.67	79.70
435.00	-355.70	0.00	1147.24	1147.24	79.98
436.00	-358.90	0.00	1143.87	1143.87	80.26
437.00	-362.10	0.00	1140.53	1140.53	80.54
438.00	-365.30	0.00	1137.24	1137.24	80.81
439.00	-368.50	0.00	1133.99	1133.99	81.08
440.00	-371.70	0.00	1130.79	1130.79	81.36
441.00	-374.90	0.00	1127.62	1127.62	81.63
442.00	-378.10	0.00	1124.50	1124.50	81.90
443.00	-381.30	0.00	1121.41	1121.41	82.17
444.00	-384.50	0.00	1118.37	1118.37	82.44
445.00	-387.70	0.00	1115.36	1115.36	82.71
446.00	-390.90	0.00	1112.39	1112.39	82.98
447.00	-394.10	0.00	1109.45	1109.45	83.25
448.00	-397.30	0.00	1106.55	1106.55	83.51
449.00	-400.50	0.00	1103.69	1103.69	83.78
450.00	-403.70	0.00	1100.86	1100.86	84.04
451.00	-406.90	0.00	1098.06	1098.06	84.31
452.00	-410.10	0.00	1095.30	1095.30	84.57
453.00	-413.30	0.00	1092.57	1092.57	84.83
454.00	-416.50	0.00	1089.87	1089.87	85.09
455.00	-419.70	0.00	1087.20	1087.20	85.35
456.00	-422.90	0.00	1084.56	1084.56	85.61
457.00	-426.10	0.00	1081.95	1081.95	85.87
458.00	-429.30	0.00	1079.37	1079.37	86.13
459.00	-432.50	0.00	1076.82	1076.82	86.39
460.00	-435.70	0.00	1074.30	1074.30	86.65
461.00	-438.90	0.00	1071.80	1071.80	86.90
462.00	-442.10	0.00	1069.33	1069.33	87.16
463.00	-445.30	0.00	1066.89	1066.89	87.41
464.00	-448.50	0.00	1064.48	1064.48	87.67
465.00	-451.70	0.00	1062.09	1062.09	87.92
466.00	-454.90	0.00	1059.72	1059.72	88.18
467.00	-458.10	0.00	1057.38	1057.38	88.43

468.00	-461.30	0.00	1055.07	1055.07	88.68
469.00	-464.50	0.00	1052.78	1052.78	88.93
470.00	-467.70	0.00	1050.51	1050.51	89.18
471.00	-470.90	0.00	1048.27	1048.27	89.43
472.00	-474.10	0.00	1046.05	1046.05	89.68
473.00	-477.30	0.00	1043.85	1043.85	89.93
474.00	-480.50	0.00	1041.67	1041.67	90.18
475.00	-483.70	0.00	1039.52	1039.52	90.42
476.00	-486.90	0.00	1037.38	1037.38	90.67
477.00	-490.10	0.00	1035.27	1035.27	90.92
478.00	-493.30	0.00	1033.18	1033.18	91.16
479.00	-496.50	0.00	1031.10	1031.10	91.40
480.00	-499.70	0.00	1029.05	1029.05	91.65
481.00	-502.90	0.00	1027.02	1027.02	91.89
482.00	-506.10	0.00	1025.01	1025.01	92.14
483.00	-509.30	0.00	1023.01	1023.01	92.38
484.00	-512.50	0.00	1021.04	1021.04	92.62
485.00	-515.70	0.00	1019.08	1019.08	92.86
486.00	-518.90	0.00	1017.14	1017.14	93.10
487.00	-522.10	0.00	1015.22	1015.22	93.34
488.00	-525.30	0.00	1013.32	1013.32	93.58
489.00	-528.50	0.00	1011.43	1011.43	93.82
490.00	-531.70	0.00	1009.56	1009.56	94.06
491.00	-534.90	0.00	1007.71	1007.71	94.30
492.00	-538.10	0.00	1005.88	1005.88	94.53
493.00	-541.30	0.00	1004.06	1004.06	94.77
494.00	-544.50	0.00	1002.25	1002.25	95.01
495.00	-547.70	0.00	1000.47	1000.47	95.24
496.00	-550.90	0.00	998.69	998.69	95.48
497.00	-554.10	0.00	996.94	996.94	95.71
498.00	-557.30	0.00	995.20	995.20	95.95
499.00	-560.50	0.00	993.47	993.47	96.18
500.00	-563.70	0.00	991.76	991.76	96.41
501.00	-566.90	0.00	990.06	990.06	96.64
502.00	-570.10	0.00	988.38	988.38	96.88
503.00	-573.30	0.00	986.71	986.71	97.11
504.00	-576.50	0.00	985.06	985.06	97.34
505.00	-579.70	0.00	983.42	983.42	97.57
506.00	-582.90	0.00	981.79	981.79	97.80
507.00	-586.10	0.00	980.17	980.17	98.03
508.00	-589.30	0.00	978.57	978.57	98.26
509.00	-592.50	0.00	976.99	976.99	98.49
510.00	-595.70	0.00	975.41	975.41	98.72
511.00	-598.90	0.00	973.85	973.85	98.94
512.00	-602.10	0.00	972.30	972.30	99.17
513.00	-605.30	0.00	970.76	970.76	99.40
514.00	-608.50	0.00	969.24	969.24	99.62
515.00	-611.70	0.00	967.72	967.72	99.85
516.00	-614.90	0.00	966.22	966.22	100.08
517.00	-618.10	0.00	964.73	964.73	100.30
518.00	-621.30	0.00	963.25	963.25	100.53
519.00	-624.50	0.00	961.79	961.79	100.75
520.00	-627.70	0.00	960.33	960.33	100.97



521.00	-630.90	0.00	958.89	958.89	101.20
522.00	-634.10	0.00	957.45	957.45	101.42
523.00	-637.30	0.00	956.03	956.03	101.64
524.00	-640.50	0.00	954.62	954.62	101.86
525.00	-643.70	0.00	953.22	953.22	102.09
526.00	-646.90	0.00	951.82	951.82	102.31
527.00	-650.10	0.00	950.44	950.44	102.53
528.00	-653.30	0.00	949.07	949.07	102.75
529.00	-656.50	0.00	947.71	947.71	102.97
530.00	-659.70	0.00	946.36	946.36	103.19
531.00	-662.90	0.00	945.02	945.02	103.41
532.00	-666.10	0.00	943.69	943.69	103.63
533.00	-669.30	0.00	942.37	942.37	103.84
534.00	-672.50	0.00	941.06	941.06	104.06
535.00	-675.70	0.00	939.75	939.75	104.28
536.00	-678.90	0.00	938.46	938.46	104.50
537.00	-682.10	0.00	937.17	937.17	104.71
538.00	-685.30	0.00	935.90	935.90	104.93
539.00	-688.50	0.00	934.63	934.63	105.15
540.00	-691.70	0.00	933.37	933.37	105.36
541.00	-694.90	0.00	932.13	932.13	105.58
542.00	-698.10	0.00	930.88	930.88	105.79
543.00	-701.30	0.00	929.65	929.65	106.01
544.00	-704.50	0.00	928.43	928.43	106.22
545.00	-707.70	0.00	927.21	927.21	106.43

Initial flashing fraction = 0.165

Initial flashing mass = 7480.936 kg

Release detected at 305.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 323.844 seconds

Wind speed for max CC concentration is 3.200 m/sec

Meander factor at this wind speed is 2.21

Hor. coeff. adjusted for meander = 68.446 m

Maximum CR concentration at 120.0 seconds after detection 77.16 ppm

## 1.4 Ton Sulfur Dioxide Release at CR 1/2

Output file is 14so2cr1.out

Accident scenario is tank failure

Mass of spill, kg = 1270.10

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed

assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Nasal detection

Detection concentration, ppm = 3.00

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 228.60

Building wake factor = 3.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 55.75

Dispersion coeff for initial flashing, m = 2.18

Unadjusted horizontal dispersion coef., m = 8.74

Unadjusted vertical dispersion coef., m = 4.55

Horizontal dispersion coefficient, m = 9.01

Vertical dispersion coefficient, m = 5.04

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	486.51	35.71

1.10	440.99	32.72
1.20	404.33	30.14
1.30	373.29	27.93
1.40	346.66	26.06
1.50	323.56	24.42
1.60	303.34	23.00
1.70	286.33	21.67
1.80	270.40	20.55
1.90	256.88	19.49
2.00	243.99	18.60
2.10	247.81	19.11
2.20	251.50	19.61
2.30	255.10	20.09
2.40	258.60	20.52
2.50	255.73	20.69
2.60	245.80	20.59
2.70	237.92	20.38
2.80	229.96	20.22
2.90	221.91	20.13
3.00	215.60	19.88
3.10	208.52	19.72
3.20	202.45	19.48
3.30	196.74	19.11
3.40	191.36	18.58
3.50	186.28	18.06
3.60	181.48	17.57
3.70	176.45	17.15
3.80	172.62	16.66
3.90	168.07	16.29
4.00	164.64	15.85
4.10	160.50	15.51
4.20	156.98	15.15
4.30	154.04	14.77
4.40	150.41	14.48
4.50	147.34	14.17
4.60	144.40	13.87
4.70	141.59	13.58
4.80	138.89	13.30
4.90	136.30	13.04
5.00	133.81	12.78
5.10	131.07	12.57
5.20	128.77	12.34
5.30	126.89	12.08
5.40	124.75	11.86
5.50	122.69	11.65
5.60	120.39	11.48
5.70	118.78	11.26
5.80	116.92	11.07
5.90	114.83	10.91
6.00	113.39	10.71

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
179.00	49.60	0.00	0.00	0.00	0.00
180.00	48.60	0.00	0.00	0.00	0.00
181.00	47.60	0.01	0.00	0.01	0.00
182.00	46.60	0.01	0.00	0.01	0.00
183.00	45.60	0.02	0.00	0.02	0.00
184.00	44.60	0.03	0.00	0.03	0.00
185.00	43.60	0.05	0.00	0.05	0.00
186.00	42.60	0.09	0.00	0.09	0.00
187.00	41.60	0.14	0.00	0.14	0.00
188.00	40.60	0.24	0.00	0.24	0.00
189.00	39.60	0.39	0.00	0.39	0.00
190.00	38.60	0.63	0.00	0.63	0.00
191.00	37.60	1.01	0.00	1.01	0.00
192.00	36.60	1.59	0.00	1.59	0.00
193.00	35.60	2.48	0.00	2.48	0.00
194.00	34.60	3.82	0.00	3.82	0.00
195.00	33.60	5.81	0.00	5.81	0.00
196.00	32.60	8.74	0.00	8.74	0.01
197.00	31.60	12.98	0.00	12.98	0.01
198.00	30.60	19.03	0.00	19.03	0.01
199.00	29.60	27.57	0.00	27.57	0.02
200.00	28.60	39.45	0.00	39.45	0.03
201.00	27.60	55.76	0.00	55.76	0.05
202.00	26.60	77.85	0.00	77.85	0.07
203.00	25.60	107.36	0.00	107.36	0.09
204.00	24.60	146.24	0.00	146.24	0.13
205.00	23.60	196.77	0.00	196.77	0.18
206.00	22.60	261.51	0.00	261.51	0.25
207.00	21.60	343.31	0.00	343.31	0.34
208.00	20.60	445.17	0.00	445.17	0.46
209.00	19.60	570.19	0.00	570.19	0.61
210.00	18.60	721.38	0.00	721.38	0.79
211.00	17.60	901.49	0.00	901.49	1.03
212.00	16.60	1112.78	0.00	1112.78	1.32
213.00	15.60	1356.79	0.00	1356.79	1.67
214.00	14.60	1546.86	0.00	1546.86	2.07
215.00	13.60	1564.79	0.00	1564.79	2.48
216.00	12.60	1581.64	0.00	1581.64	2.89
217.00	11.60	1597.37	0.00	1597.37	3.30
218.00	10.60	1611.93	0.00	1611.93	3.72
219.00	9.60	1625.30	0.00	1625.30	4.15
220.00	8.60	1637.44	0.00	1637.44	4.57
221.00	7.60	1648.32	0.00	1648.32	5.00
222.00	6.60	1657.91	0.00	1657.91	5.43
223.00	5.60	1666.20	0.00	1666.20	5.86
224.00	4.60	1673.17	0.00	1673.17	6.30
225.00	3.60	1678.78	0.00	1678.78	6.73
226.00	2.60	1683.05	0.00	1683.05	7.17

227.00	1.60	1685.94	0.00	1685.94	7.60
228.00	0.60	1687.45	0.00	1687.45	8.04
229.00	-0.40	1687.59	78.33	1765.92	8.50
230.00	-1.40	1686.35	704.36	2390.71	9.12
231.00	-2.40	1683.73	955.66	2639.39	9.80
232.00	-3.40	1679.75	1160.90	2840.64	10.54
233.00	-4.40	1674.40	1339.67	3014.07	11.32
234.00	-5.40	1667.70	1500.71	3168.41	12.14
235.00	-6.40	1659.68	1592.38	3252.06	12.99
236.00	-7.40	1650.34	1485.05	3135.39	13.80
237.00	-8.40	1639.72	1398.53	3038.25	14.59
238.00	-9.40	1627.83	1326.87	2954.69	15.35
239.00	-10.40	1614.70	1266.24	2880.94	16.10
240.00	-11.40	1600.38	1214.08	2814.46	16.83
241.00	-12.40	1584.88	1168.59	2753.47	17.54
242.00	-13.40	1568.25	1128.45	2696.70	18.24
243.00	-14.40	1550.53	1092.70	2643.23	18.92
244.00	-15.40	1409.58	1060.58	2470.16	19.56
245.00	-16.40	1158.93	1031.52	2190.45	20.12
246.00	-17.40	941.19	1005.06	1946.26	20.62
247.00	-18.40	755.01	980.84	1735.85	21.07
248.00	-19.40	598.24	958.56	1556.80	21.47
249.00	-20.40	468.22	937.98	1406.20	21.83
250.00	-21.40	361.98	918.88	1280.85	22.16
251.00	-22.40	276.41	901.09	1177.51	22.46
252.00	-23.40	208.49	884.49	1092.98	22.74
253.00	-24.40	155.34	868.93	1024.26	23.00
254.00	-25.40	114.32	854.31	968.63	23.24
255.00	-26.40	83.10	840.54	923.64	23.48
256.00	-27.40	59.67	827.55	887.22	23.70
257.00	-28.40	42.32	815.26	857.58	23.92
258.00	-29.40	29.65	803.61	833.26	24.13
259.00	-30.40	20.52	792.55	813.06	24.34
260.00	-31.40	14.02	782.03	796.05	24.54
261.00	-32.40	9.47	772.00	781.47	24.74
262.00	-33.40	6.31	762.43	768.75	24.93
263.00	-34.40	4.16	753.29	757.45	25.12
264.00	-35.40	2.71	744.55	747.25	25.31
265.00	-36.40	1.74	736.17	737.91	25.49
266.00	-37.40	1.10	728.13	729.24	25.68
267.00	-38.40	0.69	720.41	721.11	25.86
268.00	-39.40	0.43	713.00	713.42	26.04
269.00	-40.40	0.26	705.86	706.12	26.21
270.00	-41.40	0.16	698.98	699.14	26.39
271.00	-42.40	0.09	692.35	692.45	26.56
272.00	-43.40	0.06	685.95	686.01	26.73
273.00	-44.40	0.03	679.78	679.81	26.90
274.00	-45.40	0.02	673.81	673.83	27.07
275.00	-46.40	0.01	668.03	668.04	27.24
276.00	-47.40	0.01	662.44	662.45	27.40
277.00	-48.40	0.00	657.03	657.03	27.57
278.00	-49.40	0.00	651.78	651.79	27.73
279.00	-50.40	0.00	646.69	646.70	27.89

280.00	-51.40	0.00	641.76	641.76	28.05
281.00	-52.40	0.00	636.96	636.96	28.21
282.00	-53.40	0.00	632.30	632.30	28.37
283.00	-54.40	0.00	627.77	627.77	28.52
284.00	-55.40	0.00	623.37	623.37	28.68
285.00	-56.40	0.00	619.08	619.08	28.83
286.00	-57.40	0.00	614.91	614.91	28.98
287.00	-58.40	0.00	610.85	610.85	29.14
288.00	-59.40	0.00	606.88	606.88	29.29
289.00	-60.40	0.00	603.02	603.02	29.44
290.00	-61.40	0.00	599.26	599.26	29.58
291.00	-62.40	0.00	595.58	595.58	29.73
292.00	-63.40	0.00	592.00	592.00	29.88
293.00	-64.40	0.00	588.49	588.49	30.02
294.00	-65.40	0.00	585.07	585.07	30.17
295.00	-66.40	0.00	581.73	581.73	30.31
296.00	-67.40	0.00	578.46	578.46	30.45
297.00	-68.40	0.00	575.27	575.27	30.60
298.00	-69.40	0.00	572.14	572.14	30.74
299.00	-70.40	0.00	569.08	569.08	30.88
300.00	-71.40	0.00	566.09	566.09	31.02
301.00	-72.40	0.00	563.16	563.16	31.15
302.00	-73.40	0.00	560.29	560.29	31.29
303.00	-74.40	0.00	557.47	557.47	31.43
304.00	-75.40	0.00	554.72	554.72	31.56
305.00	-76.40	0.00	552.02	552.02	31.70
306.00	-77.40	0.00	549.37	549.37	31.84
307.00	-78.40	0.00	546.77	546.77	31.97
308.00	-79.40	0.00	544.22	544.22	32.10
309.00	-80.40	0.00	541.72	541.72	32.24
310.00	-81.40	0.00	539.27	539.27	32.37
311.00	-82.40	0.00	536.86	536.86	32.50
312.00	-83.40	0.00	534.50	534.50	32.63
313.00	-84.40	0.00	532.17	532.17	32.76
314.00	-85.40	0.00	529.89	529.89	32.89
315.00	-86.40	0.00	527.65	527.65	33.02
316.00	-87.40	0.00	525.45	525.45	33.15
317.00	-88.40	0.00	523.28	523.28	33.27
318.00	-89.40	0.00	521.15	521.15	33.40
319.00	-90.40	0.00	519.06	519.06	33.53
320.00	-91.40	0.00	517.00	517.00	33.65
321.00	-92.40	0.00	514.98	514.98	33.78
322.00	-93.40	0.00	512.99	512.99	33.90
323.00	-94.40	0.00	511.03	511.03	34.03
324.00	-95.40	0.00	509.10	509.10	34.15
325.00	-96.40	0.00	507.20	507.20	34.27
326.00	-97.40	0.00	505.33	505.33	34.40
327.00	-98.40	0.00	503.49	503.49	34.52
328.00	-99.40	0.00	501.68	501.68	34.64
329.00	-100.40	0.00	499.89	499.89	34.76
330.00	-101.40	0.00	498.13	498.13	34.88
331.00	-102.40	0.00	496.40	496.40	35.00
332.00	-103.40	0.00	494.69	494.69	35.12

333.00	-104.40	0.00	493.01	493.01	35.24
334.00	-105.40	0.00	491.35	491.35	35.36
335.00	-106.40	0.00	489.71	489.71	35.48
336.00	-107.40	0.00	488.10	488.10	35.60
337.00	-108.40	0.00	486.51	486.51	35.71
338.00	-109.40	0.00	484.94	484.94	35.83
339.00	-110.40	0.00	483.40	483.40	35.95
340.00	-111.40	0.00	481.87	481.87	36.06
341.00	-112.40	0.00	480.37	480.37	36.18
342.00	-113.40	0.00	478.88	478.88	36.29
343.00	-114.40	0.00	477.41	477.41	36.41
344.00	-115.40	0.00	475.97	475.97	36.52
345.00	-116.40	0.00	474.54	474.54	36.64
346.00	-117.40	0.00	473.13	473.13	36.75
347.00	-118.40	0.00	471.74	471.74	36.86
348.00	-119.40	0.00	470.37	470.37	36.98
349.00	-120.40	0.00	469.01	469.01	37.09
350.00	-121.40	0.00	467.67	467.67	37.20
351.00	-122.40	0.00	466.35	466.35	37.31
352.00	-123.40	0.00	465.04	465.04	37.42
353.00	-124.40	0.00	463.75	463.75	37.53
354.00	-125.40	0.00	462.47	462.47	37.64
355.00	-126.40	0.00	461.21	461.21	37.76
356.00	-127.40	0.00	459.97	459.97	37.87
357.00	-128.40	0.00	458.74	458.74	37.97
358.00	-129.40	0.00	457.52	457.52	38.08
359.00	-130.40	0.00	456.32	456.32	38.19
360.00	-131.40	0.00	455.13	455.13	38.30
361.00	-132.40	0.00	453.95	453.95	38.41
362.00	-133.40	0.00	452.79	452.79	38.52
363.00	-134.40	0.00	451.64	451.64	38.62
364.00	-135.40	0.00	450.51	450.51	38.73
365.00	-136.40	0.00	449.38	449.38	38.84
366.00	-137.40	0.00	448.27	448.27	38.95
367.00	-138.40	0.00	447.17	447.17	39.05
368.00	-139.40	0.00	446.09	446.09	39.16
369.00	-140.40	0.00	445.01	445.01	39.26
370.00	-141.40	0.00	443.95	443.95	39.37
371.00	-142.40	0.00	442.89	442.89	39.47
372.00	-143.40	0.00	441.85	441.85	39.58
373.00	-144.40	0.00	440.82	440.82	39.68
374.00	-145.40	0.00	439.80	439.80	39.79
375.00	-146.40	0.00	438.79	438.79	39.89
376.00	-147.40	0.00	437.79	437.79	39.99
377.00	-148.40	0.00	436.80	436.80	40.10
378.00	-149.40	0.00	435.82	435.82	40.20
379.00	-150.40	0.00	434.85	434.85	40.30
380.00	-151.40	0.00	433.89	433.89	40.41
381.00	-152.40	0.00	432.94	432.94	40.51
382.00	-153.40	0.00	432.00	432.00	40.61
383.00	-154.40	0.00	431.07	431.07	40.71
384.00	-155.40	0.00	430.15	430.15	40.81
385.00	-156.40	0.00	429.23	429.23	40.91

386.00	-157.40	0.00	428.33	428.33	41.02
387.00	-158.40	0.00	427.43	427.43	41.12
388.00	-159.40	0.00	426.54	426.54	41.22
389.00	-160.40	0.00	425.66	425.66	41.32
390.00	-161.40	0.00	424.79	424.79	41.42
391.00	-162.40	0.00	423.93	423.93	41.52
392.00	-163.40	0.00	423.07	423.07	41.61
393.00	-164.40	0.00	422.23	422.23	41.71
394.00	-165.40	0.00	421.39	421.39	41.81
395.00	-166.40	0.00	420.55	420.55	41.91
396.00	-167.40	0.00	419.73	419.73	42.01
397.00	-168.40	0.00	418.91	418.91	42.11
398.00	-169.40	0.00	418.10	418.10	42.21
399.00	-170.40	0.00	417.30	417.30	42.30
400.00	-171.40	0.00	416.50	416.50	42.40
401.00	-172.40	0.00	415.71	415.71	42.50
402.00	-173.40	0.00	414.93	414.93	42.59
403.00	-174.40	0.00	414.16	414.16	42.69
404.00	-175.40	0.00	413.39	413.39	42.79
405.00	-176.40	0.00	412.62	412.62	42.88
406.00	-177.40	0.00	411.87	411.87	42.98
407.00	-178.40	0.00	411.12	411.12	43.08
408.00	-179.40	0.00	410.38	410.38	43.17
409.00	-180.40	0.00	409.64	409.64	43.27
410.00	-181.40	0.00	408.91	408.91	43.36
411.00	-182.40	0.00	408.18	408.18	43.46
412.00	-183.40	0.00	407.46	407.46	43.55
413.00	-184.40	0.00	406.75	406.75	43.65
414.00	-185.40	0.00	406.04	406.04	43.74
415.00	-186.40	0.00	405.34	405.34	43.83
416.00	-187.40	0.00	404.65	404.65	43.93
417.00	-188.40	0.00	403.96	403.96	44.02
418.00	-189.40	0.00	403.27	403.27	44.12
419.00	-190.40	0.00	402.59	402.59	44.21
420.00	-191.40	0.00	401.92	401.92	44.30
421.00	-192.40	0.00	401.25	401.25	44.40
422.00	-193.40	0.00	400.59	400.59	44.49
423.00	-194.40	0.00	399.93	399.93	44.58
424.00	-195.40	0.00	399.28	399.28	44.67
425.00	-196.40	0.00	398.63	398.63	44.77
426.00	-197.40	0.00	397.98	397.98	44.86
427.00	-198.40	0.00	397.35	397.35	44.95
428.00	-199.40	0.00	396.71	396.71	45.04
429.00	-200.40	0.00	396.08	396.08	45.13
430.00	-201.40	0.00	395.46	395.46	45.22
431.00	-202.40	0.00	394.84	394.84	45.31
432.00	-203.40	0.00	394.22	394.22	45.40
433.00	-204.40	0.00	393.61	393.61	45.50
434.00	-205.40	0.00	393.01	393.01	45.59
435.00	-206.40	0.00	392.41	392.41	45.68
436.00	-207.40	0.00	391.81	391.81	45.77
437.00	-208.40	0.00	391.22	391.22	45.86
438.00	-209.40	0.00	390.63	390.63	45.95



439.00	-210.40	0.00	390.04	390.04	46.04
440.00	-211.40	0.00	389.46	389.46	46.12
441.00	-212.40	0.00	388.89	388.89	46.21
442.00	-213.40	0.00	388.31	388.31	46.30
443.00	-214.40	0.00	387.75	387.75	46.39
444.00	-215.40	0.00	387.18	387.18	46.48
445.00	-216.40	0.00	386.62	386.62	46.57
446.00	-217.40	0.00	386.07	386.07	46.66
447.00	-218.40	0.00	385.51	385.51	46.75
448.00	-219.40	0.00	384.96	384.96	46.83
449.00	-220.40	0.00	384.42	384.42	46.92
450.00	-221.40	0.00	383.88	383.88	47.01
451.00	-222.40	0.00	383.34	383.34	47.10
452.00	-223.40	0.00	382.81	382.81	47.18
453.00	-224.40	0.00	382.28	382.28	47.27
454.00	-225.40	0.00	381.75	381.75	47.36
455.00	-226.40	0.00	381.23	381.23	47.45
456.00	-227.40	0.00	380.71	380.71	47.53
457.00	-228.40	0.00	380.19	380.19	47.62

Initial flashing fraction = 0.165

Initial flashing mass = 209.470 kg

Release detected at 217.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 228.600 seconds

Wind speed for max CC concentration is 1.000 m/sec

Meander factor at this wind speed is 4.00

Hor. coeff. adjusted for meander = 34.972 m

Maximum CR concentration at 120.0 seconds after detection 35.71 ppm

17 Ton Cl<sub>2</sub> Release at HCT; isolation in 25 seconds  
Output file is cl2hct25.out

Accident scenario is tank failure

Mass of spill, kg = 15422.40

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 70.90

Latent heat of chemical, J/kg = 288000.00

Specific heat of chemical, J/kg-K = 946.00

Liquid density of chemical, kg/m<sup>3</sup> = 1570.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Detection at intake

Detection concentration, ppm = 5.00

Ambient temperature, K = 305.60

Boiling temperature, K = 239.10

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 5.33

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.41

Vertical dispersion coefficient, m = 15.23

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	712.34	1.11

1.10	1251.42	1.23
1.20	1888.77	1.47
1.30	2121.81	1.74
1.40	2139.01	1.97
1.50	1889.64	2.18
1.60	1718.91	2.29
1.70	1394.06	2.42
1.80	1095.59	2.44
1.90	901.76	2.50
2.00	797.83	2.51
2.10	772.34	2.66
2.20	757.86	2.90
2.30	749.25	3.08
2.40	746.73	3.19
2.50	744.48	3.39
2.60	742.31	3.58
2.70	740.12	3.77
2.80	741.75	3.97
2.90	739.39	4.23
3.00	737.02	4.59
3.10	738.18	4.76
3.20	711.06	5.04
3.30	690.92	5.08
3.40	665.79	5.36
3.50	645.15	5.89
3.60	625.70	5.75
3.70	607.33	6.45
3.80	589.96	6.42
3.90	573.51	6.78
4.00	560.25	6.94
4.10	543.11	7.62
4.20	531.18	7.37
4.30	517.70	7.66
4.40	504.86	8.57
4.50	494.55	8.51
4.60	482.79	9.14
4.70	473.37	8.71
4.80	462.55	9.01
4.90	452.20	10.09
5.00	443.94	10.09
5.10	436.00	9.94
5.20	426.76	10.60
5.30	417.88	11.14
5.40	410.85	10.59
5.50	404.07	10.87
5.60	397.52	11.04
5.70	388.40	12.08
5.80	382.34	12.03
5.90	376.48	11.89
6.00	369.51	12.54

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
141.00	190.30	0.00	0.00	0.00	0.00
142.00	184.30	0.01	0.00	0.01	0.00
143.00	178.30	0.01	0.00	0.01	0.00
144.00	172.30	0.03	0.00	0.03	0.00
145.00	166.30	0.06	0.00	0.06	0.00
146.00	160.30	0.14	0.00	0.14	0.00
147.00	154.30	0.30	0.00	0.30	0.00
148.00	148.30	0.61	0.00	0.61	0.00
149.00	142.30	1.23	0.00	1.23	0.00
150.00	136.30	2.40	0.00	2.40	0.00
151.00	130.30	4.54	0.00	4.54	0.00
152.00	124.30	8.35	0.00	8.35	0.00
153.00	118.30	14.93	0.00	14.93	0.01
154.00	112.30	25.92	0.00	25.92	0.02
155.00	106.30	43.73	0.00	43.73	0.03
156.00	100.30	71.70	0.00	71.70	0.05
157.00	94.30	114.22	0.00	114.22	0.07
158.00	88.30	176.80	0.00	176.80	0.12
159.00	82.30	265.94	0.00	265.94	0.19
160.00	76.30	388.68	0.00	388.68	0.29
161.00	70.30	552.00	0.00	552.00	0.43
162.00	64.30	761.75	0.00	761.75	0.63
163.00	58.30	1021.44	0.00	1021.44	0.90
164.00	52.30	1330.91	0.00	1330.91	1.24
165.00	46.30	1685.05	0.00	1685.05	1.68
166.00	40.30	2073.03	0.00	2073.03	2.22
167.00	34.30	2478.16	0.00	2478.16	2.87
168.00	28.30	2878.60	0.00	2878.60	3.62
169.00	22.30	3249.11	0.00	3249.11	4.46
170.00	16.30	3563.50	0.00	3563.50	5.39
171.00	10.30	3797.69	0.00	3797.69	6.37
172.00	4.30	3932.70	0.00	3932.70	7.40
173.00	-1.70	3957.25	19.73	3976.97	8.43
174.00	-7.70	3869.23	126.16	3995.39	9.47
175.00	-13.70	3676.09	167.34	3843.43	10.46
176.00	-19.70	3393.73	201.74	3595.47	11.40
177.00	-25.70	3044.38	232.01	3276.38	11.46
178.00	-31.70	2653.68	259.45	2913.13	11.52
179.00	-37.70	2247.66	284.80	2532.45	11.57
180.00	-43.70	1849.87	308.52	2158.38	11.61
181.00	-49.70	1479.38	330.92	1810.30	11.65
182.00	-55.70	1149.61	352.22	1501.83	11.68
183.00	-61.70	868.06	372.58	1240.64	11.70
184.00	-67.70	636.91	392.13	1029.04	11.72
185.00	-73.70	454.09	410.97	865.05	11.74
186.00	-79.70	314.58	429.17	743.74	11.75
187.00	-85.70	211.76	446.79	658.55	11.77
188.00	-91.70	138.51	463.90	602.41	11.78

189.00	-97.70	88.04	480.52	568.56	11.79
190.00	-103.70	54.37	496.71	551.09	11.80
191.00	-109.70	32.63	512.49	545.12	11.81
192.00	-115.70	19.03	527.90	546.92	11.82
193.00	-121.70	10.78	542.94	553.72	11.83
194.00	-127.70	5.94	557.65	563.59	11.84
195.00	-133.70	3.18	572.05	575.22	11.86
196.00	-139.70	1.65	586.14	587.80	11.87
197.00	-145.70	0.83	599.96	600.79	11.88
198.00	-151.70	0.41	613.49	613.90	11.89
199.00	-157.70	0.20	612.67	612.87	11.90
200.00	-163.70	0.09	603.35	603.44	11.91
201.00	-169.70	0.04	594.53	594.57	11.93
202.00	-175.70	0.02	586.17	586.19	11.94
203.00	-181.70	0.01	578.23	578.24	11.95
204.00	-187.70	0.00	570.68	570.68	11.96
205.00	-193.70	0.00	563.49	563.49	11.97
206.00	-199.70	0.00	556.62	556.62	11.98
207.00	-205.70	0.00	550.06	550.06	11.99
208.00	-211.70	0.00	543.79	543.79	12.00
209.00	-217.70	0.00	537.77	537.77	12.01
210.00	-223.70	0.00	532.01	532.01	12.02
211.00	-229.70	0.00	526.47	526.47	12.03
212.00	-235.70	0.00	521.15	521.15	12.04
213.00	-241.70	0.00	516.02	516.02	12.05
214.00	-247.70	0.00	511.09	511.09	12.06
215.00	-253.70	0.00	506.33	506.33	12.07
216.00	-259.70	0.00	501.74	501.74	12.08
217.00	-265.70	0.00	497.31	497.31	12.09
218.00	-271.70	0.00	493.03	493.03	12.10
219.00	-277.70	0.00	488.88	488.88	12.11
220.00	-283.70	0.00	484.87	484.87	12.12
221.00	-289.70	0.00	480.99	480.99	12.13
222.00	-295.70	0.00	477.22	477.22	12.14
223.00	-301.70	0.00	473.57	473.57	12.15
224.00	-307.70	0.00	470.03	470.03	12.16
225.00	-313.70	0.00	466.59	466.59	12.17
226.00	-319.70	0.00	463.24	463.24	12.18
227.00	-325.70	0.00	459.99	459.99	12.18
228.00	-331.70	0.00	456.83	456.83	12.19
229.00	-337.70	0.00	453.76	453.76	12.20
230.00	-343.70	0.00	450.76	450.76	12.21
231.00	-349.70	0.00	447.85	447.85	12.22
232.00	-355.70	0.00	445.00	445.00	12.23
233.00	-361.70	0.00	442.23	442.23	12.24
234.00	-367.70	0.00	439.53	439.53	12.25
235.00	-373.70	0.00	436.89	436.89	12.25
236.00	-379.70	0.00	434.32	434.32	12.26
237.00	-385.70	0.00	431.81	431.81	12.27
238.00	-391.70	0.00	429.35	429.35	12.28
239.00	-397.70	0.00	426.95	426.95	12.29
240.00	-403.70	0.00	424.61	424.61	12.30
241.00	-409.70	0.00	422.32	422.32	12.30

242.00	-415.70	0.00	420.07	420.07	12.31
243.00	-421.70	0.00	417.88	417.88	12.32
244.00	-427.70	0.00	415.73	415.73	12.33
245.00	-433.70	0.00	413.63	413.63	12.34
246.00	-439.70	0.00	411.57	411.57	12.34
247.00	-445.70	0.00	409.55	409.55	12.35
248.00	-451.70	0.00	407.57	407.57	12.36
249.00	-457.70	0.00	405.63	405.63	12.37
250.00	-463.70	0.00	403.73	403.73	12.37
251.00	-469.70	0.00	401.87	401.87	12.38
252.00	-475.70	0.00	400.04	400.04	12.39
253.00	-481.70	0.00	398.25	398.25	12.40
254.00	-487.70	0.00	396.49	396.49	12.41
255.00	-493.70	0.00	394.76	394.76	12.41
256.00	-499.70	0.00	393.06	393.06	12.42
257.00	-505.70	0.00	391.39	391.39	12.43
258.00	-511.70	0.00	389.76	389.76	12.44
259.00	-517.70	0.00	388.15	388.15	12.44
260.00	-523.70	0.00	386.57	386.57	12.45
261.00	-529.70	0.00	385.01	385.01	12.46
262.00	-535.70	0.00	383.49	383.49	12.47
263.00	-541.70	0.00	381.98	381.98	12.47
264.00	-547.70	0.00	380.51	380.51	12.48
265.00	-553.70	0.00	379.06	379.06	12.49
266.00	-559.70	0.00	377.63	377.63	12.49
267.00	-565.70	0.00	376.22	376.22	12.50
268.00	-571.70	0.00	374.83	374.83	12.51
269.00	-577.70	0.00	373.47	373.47	12.52
270.00	-583.70	0.00	372.13	372.13	12.52
271.00	-589.70	0.00	370.81	370.81	12.53
272.00	-595.70	0.00	369.51	369.51	12.54
273.00	-601.70	0.00	368.23	368.23	12.54
274.00	-607.70	0.00	366.97	366.97	12.55
275.00	-613.70	0.00	365.72	365.72	12.56
276.00	-619.70	0.00	364.50	364.50	12.57
277.00	-625.70	0.00	363.29	363.29	12.57
278.00	-631.70	0.00	362.10	362.10	12.58
279.00	-637.70	0.00	360.93	360.93	12.59
280.00	-643.70	0.00	359.77	359.77	12.59
281.00	-649.70	0.00	358.63	358.63	12.60
282.00	-655.70	0.00	357.50	357.50	12.61
283.00	-661.70	0.00	356.39	356.39	12.61
284.00	-667.70	0.00	355.30	355.30	12.62
285.00	-673.70	0.00	354.22	354.22	12.63
286.00	-679.70	0.00	353.15	353.15	12.63
287.00	-685.70	0.00	352.10	352.10	12.64
288.00	-691.70	0.00	351.06	351.06	12.65
289.00	-697.70	0.00	350.04	350.04	12.65
290.00	-703.70	0.00	349.03	349.03	12.66
291.00	-709.70	0.00	348.03	348.03	12.67
292.00	-715.70	0.00	347.04	347.04	12.67
293.00	-721.70	0.00	346.07	346.07	12.68
294.00	-727.70	0.00	345.11	345.11	12.69

295.00	-733.70	0.00	344.16	344.16	12.69
296.00	-739.70	0.00	343.22	343.22	12.70
297.00	-745.70	0.00	342.29	342.29	12.71
298.00	-751.70	0.00	341.38	341.38	12.71
299.00	-757.70	0.00	340.47	340.47	12.72
300.00	-763.70	0.00	339.58	339.58	12.73
301.00	-769.70	0.00	338.70	338.70	12.73
302.00	-775.70	0.00	337.82	337.82	12.74
303.00	-781.70	0.00	336.96	336.96	12.75
304.00	-787.70	0.00	336.11	336.11	12.75
305.00	-793.70	0.00	335.27	335.27	12.76
306.00	-799.70	0.00	334.43	334.43	12.77
307.00	-805.70	0.00	333.61	333.61	12.77
308.00	-811.70	0.00	332.79	332.79	12.78
309.00	-817.70	0.00	331.99	331.99	12.78
310.00	-823.70	0.00	331.19	331.19	12.79
311.00	-829.70	0.00	330.40	330.40	12.80
312.00	-835.70	0.00	329.62	329.62	12.80
313.00	-841.70	0.00	328.85	328.85	12.81
314.00	-847.70	0.00	328.08	328.08	12.82
315.00	-853.70	0.00	327.33	327.33	12.82
316.00	-859.70	0.00	326.58	326.58	12.83
317.00	-865.70	0.00	325.84	325.84	12.83
318.00	-871.70	0.00	325.11	325.11	12.84
319.00	-877.70	0.00	324.39	324.39	12.85
320.00	-883.70	0.00	323.67	323.67	12.85
321.00	-889.70	0.00	322.96	322.96	12.86
322.00	-895.70	0.00	322.26	322.26	12.87
323.00	-901.70	0.00	321.56	321.56	12.87
324.00	-907.70	0.00	320.87	320.87	12.88
325.00	-913.70	0.00	320.19	320.19	12.88
326.00	-919.70	0.00	319.51	319.51	12.89
327.00	-925.70	0.00	318.85	318.85	12.90
328.00	-931.70	0.00	318.18	318.18	12.90
329.00	-937.70	0.00	317.53	317.53	12.91
330.00	-943.70	0.00	316.88	316.88	12.91
331.00	-949.70	0.00	316.23	316.23	12.92
332.00	-955.70	0.00	315.60	315.60	12.93
333.00	-961.70	0.00	314.97	314.97	12.93
334.00	-967.70	0.00	314.34	314.34	12.94
335.00	-973.70	0.00	313.72	313.72	12.94
336.00	-979.70	0.00	313.11	313.11	12.95
337.00	-985.70	0.00	312.50	312.50	12.96
338.00	-991.70	0.00	311.90	311.90	12.96
339.00	-997.70	0.00	311.30	311.30	12.97
340.00	-1003.70	0.00	310.71	310.71	12.97
341.00	-1009.70	0.00	310.12	310.12	12.98
342.00	-1015.70	0.00	309.54	309.54	12.99
343.00	-1021.70	0.00	308.96	308.96	12.99
344.00	-1027.70	0.00	308.39	308.39	13.00
345.00	-1033.70	0.00	307.83	307.83	13.00
346.00	-1039.70	0.00	307.26	307.26	13.01
347.00	-1045.70	0.00	306.71	306.71	13.02

348.00	-1051.70	0.00	306.16	306.16	13.02
349.00	-1057.70	0.00	305.61	305.61	13.03
350.00	-1063.70	0.00	305.07	305.07	13.03
351.00	-1069.70	0.00	304.53	304.53	13.04
352.00	-1075.70	0.00	304.00	304.00	13.04
353.00	-1081.70	0.00	303.47	303.47	13.05
354.00	-1087.70	0.00	302.94	302.94	13.06
355.00	-1093.70	0.00	302.42	302.42	13.06
356.00	-1099.70	0.00	301.91	301.91	13.07
357.00	-1105.70	0.00	301.40	301.40	13.07
358.00	-1111.70	0.00	300.89	300.89	13.08
359.00	-1117.70	0.00	300.38	300.38	13.08
360.00	-1123.70	0.00	299.89	299.89	13.09
361.00	-1129.70	0.00	299.39	299.39	13.10
362.00	-1135.70	0.00	298.90	298.90	13.10
363.00	-1141.70	0.00	298.41	298.41	13.11
364.00	-1147.70	0.00	297.93	297.93	13.11
365.00	-1153.70	0.00	297.45	297.45	13.12
366.00	-1159.70	0.00	296.97	296.97	13.12
367.00	-1165.70	0.00	296.50	296.50	13.13
368.00	-1171.70	0.00	296.03	296.03	13.14
369.00	-1177.70	0.00	295.57	295.57	13.14
370.00	-1183.70	0.00	295.10	295.10	13.15
371.00	-1189.70	0.00	294.65	294.65	13.15
372.00	-1195.70	0.00	294.19	294.19	13.16
373.00	-1201.70	0.00	293.74	293.74	13.16
374.00	-1207.70	0.00	293.29	293.29	13.17
375.00	-1213.70	0.00	292.85	292.85	13.17
376.00	-1219.70	0.00	292.41	292.41	13.18
377.00	-1225.70	0.00	291.97	291.97	13.19
378.00	-1231.70	0.00	291.53	291.53	13.19
379.00	-1237.70	0.00	291.10	291.10	13.20
380.00	-1243.70	0.00	290.67	290.67	13.20
381.00	-1249.70	0.00	290.25	290.25	13.21
382.00	-1255.70	0.00	289.83	289.83	13.21
383.00	-1261.70	0.00	289.41	289.41	13.22
384.00	-1267.70	0.00	288.99	288.99	13.22
385.00	-1273.70	0.00	288.58	288.58	13.23
386.00	-1279.70	0.00	288.17	288.17	13.23
387.00	-1285.70	0.00	287.76	287.76	13.24
388.00	-1291.70	0.00	287.35	287.35	13.25
389.00	-1297.70	0.00	286.95	286.95	13.25
390.00	-1303.70	0.00	286.55	286.55	13.26
391.00	-1309.70	0.00	286.16	286.16	13.26
392.00	-1315.70	0.00	285.76	285.76	13.27

Initial flashing fraction = 0.218

Initial flashing mass = 3368.777 kg

Release detected at 152.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 172.717 seconds



Wind speed for max CC concentration is 6.000 m/sec

Meander factor at this wind speed is 1.00

Hor. coeff. adjusted for meander = 34.998 m

Maximum CR concentration at 120.0 seconds after detection 12.54 ppm

17 Ton Cl<sub>2</sub> Release at HCT; isolation in 29 seconds  
Output file is cl2hct29.out

Accident scenario is tank failure

Mass of spill, kg = 15422.40

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 70.90

Latent heat of chemical, J/kg = 288000.00

Specific heat of chemical, J/kg-K = 946.00

Liquid density of chemical, kg/m<sup>3</sup> = 1570.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed

assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Detection at intake

Detection concentration, ppm = 5.00

Ambient temperature, K = 305.60

Boiling temperature, K = 239.10

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 5.33

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.41

Vertical dispersion coefficient, m = 15.23

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	712.34	1.17

1.10	1251.42	1.30
1.20	1888.77	1.56
1.30	2121.81	1.85
1.40	2139.01	2.10
1.50	1889.64	2.34
1.60	1718.91	2.48
1.70	1394.06	2.65
1.80	1095.59	2.71
1.90	901.76	2.85
2.00	797.83	2.91
2.10	772.34	3.10
2.20	757.86	3.46
2.30	749.25	3.73
2.40	746.73	3.88
2.50	744.48	4.19
2.60	742.31	4.48
2.70	740.12	4.77
2.80	741.75	5.08
2.90	739.39	5.47
3.00	737.02	5.99
3.10	738.18	6.27
3.20	711.06	6.69
3.30	690.92	6.85
3.40	665.79	7.28
3.50	645.15	8.03
3.60	625.70	7.99
3.70	607.33	8.95
3.80	589.96	9.05
3.90	573.51	9.61
4.00	560.25	9.95
4.10	543.11	10.89
4.20	531.18	10.69
4.30	517.70	11.10
4.40	504.86	12.22
4.50	494.55	12.17
4.60	482.79	12.88
4.70	473.37	12.44
4.80	462.55	12.80
4.90	452.20	13.89
5.00	443.94	13.87
5.10	436.00	13.71
5.20	426.76	14.30
5.30	417.88	14.73
5.40	410.85	14.25
5.50	404.07	14.41
5.60	397.52	14.46
5.70	388.40	15.15
5.80	382.34	15.02
5.90	376.48	14.84
6.00	369.51	15.14

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Time history for limiting wind speed of 5.70 m/sec



time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
148.00	192.70	0.00	0.00	0.00	0.00
149.00	187.00	0.00	0.00	0.00	0.00
150.00	181.30	0.01	0.00	0.01	0.00
151.00	175.60	0.02	0.00	0.02	0.00
152.00	169.90	0.04	0.00	0.04	0.00
153.00	164.20	0.08	0.00	0.08	0.00
154.00	158.50	0.18	0.00	0.18	0.00
155.00	152.80	0.36	0.00	0.36	0.00
156.00	147.10	0.71	0.00	0.71	0.00
157.00	141.40	1.36	0.00	1.36	0.00
158.00	135.70	2.56	0.00	2.56	0.00
159.00	130.00	4.69	0.00	4.69	0.00
160.00	124.30	8.35	0.00	8.35	0.00
161.00	118.60	14.51	0.00	14.51	0.01
162.00	112.90	24.56	0.00	24.56	0.01
163.00	107.20	40.51	0.00	40.51	0.03
164.00	101.50	65.10	0.00	65.10	0.04
165.00	95.80	101.94	0.00	101.94	0.07
166.00	90.10	155.55	0.00	155.55	0.11
167.00	84.40	231.28	0.00	231.28	0.17
168.00	78.70	335.09	0.00	335.09	0.26
169.00	73.00	473.07	0.00	473.07	0.38
170.00	67.30	650.78	0.00	650.78	0.55
171.00	61.60	872.34	0.00	872.34	0.78
172.00	55.90	1139.42	0.00	1139.42	1.07
173.00	50.20	1450.20	0.00	1450.20	1.45
174.00	44.50	1798.54	0.00	1798.54	1.92
175.00	38.80	2173.48	0.00	2173.48	2.48
176.00	33.10	2559.39	0.00	2559.39	3.15
177.00	27.40	2936.73	0.00	2936.73	3.91
178.00	21.70	3283.50	0.00	3283.50	4.77
179.00	16.00	3577.30	0.00	3577.30	5.70
180.00	10.30	3797.69	0.00	3797.69	6.68
181.00	4.60	3928.52	0.00	3928.52	7.70
182.00	-1.10	3959.90	20.75	3980.65	8.74
183.00	-6.80	3889.42	132.70	4022.12	9.78
184.00	-12.50	3722.47	175.97	3898.45	10.79
185.00	-18.20	3471.55	212.11	3683.66	11.75
186.00	-23.90	3154.73	243.89	3398.62	12.63
187.00	-29.60	2793.48	272.70	3066.18	13.43
188.00	-35.30	2410.32	299.31	2709.63	14.13
189.00	-41.00	2026.51	324.20	2350.71	14.17
190.00	-46.70	1660.23	347.70	2007.94	14.21
191.00	-52.40	1325.36	370.05	1695.41	14.25
192.00	-58.10	1030.97	391.41	1422.38	14.28
193.00	-63.80	781.45	411.91	1193.37	14.30
194.00	-69.50	577.17	431.67	1008.84	14.32
195.00	-75.20	415.39	450.75	866.14	14.34



196.00	-80.90	291.31	469.23	760.53	14.35
197.00	-86.60	199.06	487.16	686.22	14.36
198.00	-92.30	132.55	504.59	637.14	14.38
199.00	-98.00	86.00	521.56	607.56	14.39
200.00	-103.70	54.37	538.10	592.47	14.40
201.00	-109.40	33.50	554.24	587.73	14.41
202.00	-115.10	20.11	570.00	590.11	14.42
203.00	-120.80	11.76	585.42	597.18	14.43
204.00	-126.50	6.70	600.50	607.20	14.45
205.00	-132.20	3.72	615.27	618.99	14.46
206.00	-137.90	2.02	629.73	631.75	14.47
207.00	-143.60	1.06	643.91	644.98	14.48
208.00	-149.30	0.55	642.98	643.53	14.50
209.00	-155.00	0.27	633.17	633.44	14.51
210.00	-160.70	0.13	623.89	624.02	14.52
211.00	-166.40	0.06	615.09	615.15	14.53
212.00	-172.10	0.03	606.73	606.76	14.54
213.00	-177.80	0.01	598.78	598.80	14.56
214.00	-183.50	0.01	591.21	591.22	14.57
215.00	-189.20	0.00	583.99	583.99	14.58
216.00	-194.90	0.00	577.08	577.08	14.59
217.00	-200.60	0.00	570.48	570.48	14.60
218.00	-206.30	0.00	564.15	564.15	14.61
219.00	-212.00	0.00	558.08	558.08	14.62
220.00	-217.70	0.00	552.25	552.25	14.63
221.00	-223.40	0.00	546.64	546.64	14.64
222.00	-229.10	0.00	541.25	541.25	14.65
223.00	-234.80	0.00	536.06	536.06	14.66
224.00	-240.50	0.00	531.05	531.05	14.67
225.00	-246.20	0.00	526.22	526.22	14.68
226.00	-251.90	0.00	521.55	521.55	14.69
227.00	-257.60	0.00	517.04	517.04	14.70
228.00	-263.30	0.00	512.68	512.68	14.71
229.00	-269.00	0.00	508.46	508.46	14.72
230.00	-274.70	0.00	504.37	504.37	14.73
231.00	-280.40	0.00	500.41	500.41	14.74
232.00	-286.10	0.00	496.56	496.56	14.75
233.00	-291.80	0.00	492.83	492.83	14.76
234.00	-297.50	0.00	489.21	489.21	14.77
235.00	-303.20	0.00	485.69	485.69	14.78
236.00	-308.90	0.00	482.27	482.27	14.79
237.00	-314.60	0.00	478.95	478.95	14.80
238.00	-320.30	0.00	475.71	475.71	14.81
239.00	-326.00	0.00	472.56	472.56	14.82
240.00	-331.70	0.00	469.49	469.49	14.83
241.00	-337.40	0.00	466.49	466.49	14.84
242.00	-343.10	0.00	463.58	463.58	14.84
243.00	-348.80	0.00	460.73	460.73	14.85
244.00	-354.50	0.00	457.96	457.96	14.86
245.00	-360.20	0.00	455.25	455.25	14.87
246.00	-365.90	0.00	452.60	452.60	14.88
247.00	-371.60	0.00	450.02	450.02	14.89
248.00	-377.30	0.00	447.49	447.49	14.90



249.00	-383.00	0.00	445.03	445.03	14.91
250.00	-388.70	0.00	442.61	442.61	14.91
251.00	-394.40	0.00	440.25	440.25	14.92
252.00	-400.10	0.00	437.94	437.94	14.93
253.00	-405.80	0.00	435.68	435.68	14.94
254.00	-411.50	0.00	433.47	433.47	14.95
255.00	-417.20	0.00	431.30	431.30	14.96
256.00	-422.90	0.00	429.17	429.17	14.96
257.00	-428.60	0.00	427.09	427.09	14.97
258.00	-434.30	0.00	425.05	425.05	14.98
259.00	-440.00	0.00	423.05	423.05	14.99
260.00	-445.70	0.00	421.09	421.09	15.00
261.00	-451.40	0.00	419.16	419.16	15.00
262.00	-457.10	0.00	417.28	417.28	15.01
263.00	-462.80	0.00	415.42	415.42	15.02
264.00	-468.50	0.00	413.60	413.60	15.03
265.00	-474.20	0.00	411.82	411.82	15.04
266.00	-479.90	0.00	410.06	410.06	15.04
267.00	-485.60	0.00	408.34	408.34	15.05
268.00	-491.30	0.00	406.65	406.65	15.06
269.00	-497.00	0.00	404.98	404.98	15.07
270.00	-502.70	0.00	403.35	403.35	15.08
271.00	-508.40	0.00	401.74	401.74	15.08
272.00	-514.10	0.00	400.16	400.16	15.09
273.00	-519.80	0.00	398.60	398.60	15.10
274.00	-525.50	0.00	397.07	397.07	15.11
275.00	-531.20	0.00	395.57	395.57	15.11
276.00	-536.90	0.00	394.09	394.09	15.12
277.00	-542.60	0.00	392.63	392.63	15.13
278.00	-548.30	0.00	391.20	391.20	15.14
279.00	-554.00	0.00	389.79	389.79	15.14
280.00	-559.70	0.00	388.40	388.40	15.15
281.00	-565.40	0.00	387.03	387.03	15.16
282.00	-571.10	0.00	385.68	385.68	15.17
283.00	-576.80	0.00	384.35	384.35	15.17
284.00	-582.50	0.00	383.04	383.04	15.18
285.00	-588.20	0.00	381.75	381.75	15.19
286.00	-593.90	0.00	380.48	380.48	15.19
287.00	-599.60	0.00	379.23	379.23	15.20
288.00	-605.30	0.00	377.99	377.99	15.21
289.00	-611.00	0.00	376.77	376.77	15.22
290.00	-616.70	0.00	375.57	375.57	15.22
291.00	-622.40	0.00	374.39	374.39	15.23
292.00	-628.10	0.00	373.22	373.22	15.24
293.00	-633.80	0.00	372.07	372.07	15.25
294.00	-639.50	0.00	370.93	370.93	15.25
295.00	-645.20	0.00	369.81	369.81	15.26
296.00	-650.90	0.00	368.70	368.70	15.27
297.00	-656.60	0.00	367.61	367.61	15.27
298.00	-662.30	0.00	366.53	366.53	15.28
299.00	-668.00	0.00	365.47	365.47	15.29
300.00	-673.70	0.00	364.42	364.42	15.29
301.00	-679.40	0.00	363.38	363.38	15.30



302.00	-685.10	0.00	362.35	362.35	15.31
303.00	-690.80	0.00	361.34	361.34	15.31
304.00	-696.50	0.00	360.34	360.34	15.32
305.00	-702.20	0.00	359.35	359.35	15.33
306.00	-707.90	0.00	358.38	358.38	15.34
307.00	-713.60	0.00	357.42	357.42	15.34
308.00	-719.30	0.00	356.46	356.46	15.35
309.00	-725.00	0.00	355.52	355.52	15.36
310.00	-730.70	0.00	354.59	354.59	15.36
311.00	-736.40	0.00	353.67	353.67	15.37
312.00	-742.10	0.00	352.77	352.77	15.38
313.00	-747.80	0.00	351.87	351.87	15.38
314.00	-753.50	0.00	350.98	350.98	15.39
315.00	-759.20	0.00	350.10	350.10	15.40
316.00	-764.90	0.00	349.23	349.23	15.40
317.00	-770.60	0.00	348.38	348.38	15.41
318.00	-776.30	0.00	347.53	347.53	15.42
319.00	-782.00	0.00	346.69	346.69	15.42
320.00	-787.70	0.00	345.86	345.86	15.43
321.00	-793.40	0.00	345.04	345.04	15.44
322.00	-799.10	0.00	344.22	344.22	15.44
323.00	-804.80	0.00	343.42	343.42	15.45
324.00	-810.50	0.00	342.63	342.63	15.45
325.00	-816.20	0.00	341.84	341.84	15.46
326.00	-821.90	0.00	341.06	341.06	15.47
327.00	-827.60	0.00	340.29	340.29	15.47
328.00	-833.30	0.00	339.53	339.53	15.48
329.00	-839.00	0.00	338.77	338.77	15.49
330.00	-844.70	0.00	338.02	338.02	15.49
331.00	-850.40	0.00	337.29	337.29	15.50
332.00	-856.10	0.00	336.55	336.55	15.51
333.00	-861.80	0.00	335.83	335.83	15.51
334.00	-867.50	0.00	335.11	335.11	15.52
335.00	-873.20	0.00	334.40	334.40	15.53
336.00	-878.90	0.00	333.70	333.70	15.53
337.00	-884.60	0.00	333.00	333.00	15.54
338.00	-890.30	0.00	332.31	332.31	15.54
339.00	-896.00	0.00	331.62	331.62	15.55
340.00	-901.70	0.00	330.95	330.95	15.56
341.00	-907.40	0.00	330.28	330.28	15.56
342.00	-913.10	0.00	329.61	329.61	15.57
343.00	-918.80	0.00	328.95	328.95	15.58
344.00	-924.50	0.00	328.30	328.30	15.58
345.00	-930.20	0.00	327.66	327.66	15.59
346.00	-935.90	0.00	327.02	327.02	15.59
347.00	-941.60	0.00	326.38	326.38	15.60
348.00	-947.30	0.00	325.75	325.75	15.61
349.00	-953.00	0.00	325.13	325.13	15.61
350.00	-958.70	0.00	324.51	324.51	15.62
351.00	-964.40	0.00	323.90	323.90	15.62
352.00	-970.10	0.00	323.29	323.29	15.63
353.00	-975.80	0.00	322.69	322.69	15.64
354.00	-981.50	0.00	322.10	322.10	15.64



355.00	-987.20	0.00	321.51	321.51	15.65
356.00	-992.90	0.00	320.92	320.92	15.66
357.00	-998.60	0.00	320.34	320.34	15.66
358.00	-1004.30	0.00	319.76	319.76	15.67
359.00	-1010.00	0.00	319.19	319.19	15.67
360.00	-1015.70	0.00	318.63	318.63	15.68
361.00	-1021.40	0.00	318.07	318.07	15.69
362.00	-1027.10	0.00	317.51	317.51	15.69
363.00	-1032.80	0.00	316.96	316.96	15.70
364.00	-1038.50	0.00	316.41	316.41	15.70
365.00	-1044.20	0.00	315.87	315.87	15.71
366.00	-1049.90	0.00	315.33	315.33	15.72
367.00	-1055.60	0.00	314.79	314.79	15.72
368.00	-1061.30	0.00	314.26	314.26	15.73
369.00	-1067.00	0.00	313.74	313.74	15.73
370.00	-1072.70	0.00	313.22	313.22	15.74
371.00	-1078.40	0.00	312.70	312.70	15.74
372.00	-1084.10	0.00	312.19	312.19	15.75
373.00	-1089.80	0.00	311.68	311.68	15.76
374.00	-1095.50	0.00	311.17	311.17	15.76
375.00	-1101.20	0.00	310.67	310.67	15.77
376.00	-1106.90	0.00	310.17	310.17	15.77
377.00	-1112.60	0.00	309.68	309.68	15.78
378.00	-1118.30	0.00	309.19	309.19	15.79
379.00	-1124.00	0.00	308.70	308.70	15.79
380.00	-1129.70	0.00	308.22	308.22	15.80
381.00	-1135.40	0.00	307.74	307.74	15.80
382.00	-1141.10	0.00	307.27	307.27	15.81
383.00	-1146.80	0.00	306.80	306.80	15.81
384.00	-1152.50	0.00	306.33	306.33	15.82
385.00	-1158.20	0.00	305.86	305.86	15.83
386.00	-1163.90	0.00	305.40	305.40	15.83
387.00	-1169.60	0.00	304.95	304.95	15.84
388.00	-1175.30	0.00	304.49	304.49	15.84
389.00	-1181.00	0.00	304.04	304.04	15.85
390.00	-1186.70	0.00	303.59	303.59	15.86
391.00	-1192.40	0.00	303.15	303.15	15.86
392.00	-1198.10	0.00	302.71	302.71	15.87
393.00	-1203.80	0.00	302.27	302.27	15.87
394.00	-1209.50	0.00	301.83	301.83	15.88
395.00	-1215.20	0.00	301.40	301.40	15.88
396.00	-1220.90	0.00	300.97	300.97	15.89
397.00	-1226.60	0.00	300.55	300.55	15.89
398.00	-1232.30	0.00	300.12	300.12	15.90
399.00	-1238.00	0.00	299.70	299.70	15.91
400.00	-1243.70	0.00	299.29	299.29	15.91

Initial flashing fraction = 0.218

Initial flashing mass = 3368.777 kg

Release detected at 160.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00



Arrival time of plume at intake 181.807 seconds

Wind speed for max CC concentration is 5.700 m/sec

Meander factor at this wind speed is 1.07

Hor. coeff. adjusted for meander = 36.845 m

Maximum CR concentration at 120.0 seconds after detection 15.15 ppm



50 Ton Sulfur Dioxide Release at HCT; 30 second isolation  
Output file is so2hct30.out

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Accident scenario is tank failure

Mass of spill, kg = 45360.00

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Detection at intake

Detection concentration, ppm = 2.40

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 7.19

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.74

Vertical dispersion coefficient, m = 15.98

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

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Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	1638.00	1.94

1.10	1664.23	2.17
1.20	1673.13	2.35
1.30	2507.24	2.63
1.40	2778.41	2.95
1.50	2932.13	3.31
1.60	2962.90	3.61
1.70	2937.85	3.85
1.80	2665.35	4.11
1.90	2056.26	4.27
2.00	1727.36	4.30
2.10	1538.62	4.75
2.20	1459.09	5.21
2.30	1424.13	5.55
2.40	1402.97	6.03
2.50	1396.23	6.44
2.60	1390.93	6.81
2.70	1378.53	7.65
2.80	1381.23	8.09
2.90	1376.48	8.69
3.00	1371.77	9.52
3.10	1363.48	9.88
3.20	1310.82	10.54
3.30	1267.56	11.66
3.40	1221.44	12.41
3.50	1188.71	12.61
3.60	1147.69	13.54
3.70	1118.67	13.96
3.80	1081.96	15.34
3.90	1051.72	16.30
4.00	1027.22	16.75
4.10	995.82	18.49
4.20	969.95	19.79
4.30	945.33	20.61
4.40	925.41	20.95
4.50	902.91	22.94
4.60	884.75	22.37
4.70	864.10	23.53
4.80	844.35	24.31
4.90	828.47	24.68
5.00	810.25	26.88
5.10	795.63	26.55
5.20	778.77	28.06
5.30	762.59	29.21
5.40	747.03	30.05
5.50	734.59	30.52
5.60	722.59	30.74
5.70	708.57	30.82
5.80	697.42	30.64
5.90	684.32	31.84
6.00	673.93	31.35

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Time history for limiting wind speed of 5.90 m/sec



time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
142.00	198.50	0.00	0.00	0.00	0.00
143.00	192.60	0.00	0.00	0.00	0.00
144.00	186.70	0.01	0.00	0.01	0.00
145.00	180.80	0.03	0.00	0.03	0.00
146.00	174.90	0.06	0.00	0.06	0.00
147.00	169.00	0.13	0.00	0.13	0.00
148.00	163.10	0.27	0.00	0.27	0.00
149.00	157.20	0.57	0.00	0.57	0.00
150.00	151.30	1.17	0.00	1.17	0.00
151.00	145.40	2.32	0.00	2.32	0.00
152.00	139.50	4.47	0.00	4.47	0.00
153.00	133.60	8.40	0.00	8.40	0.00
154.00	127.70	15.37	0.00	15.37	0.01
155.00	121.80	27.34	0.00	27.34	0.02
156.00	115.90	47.35	0.00	47.35	0.03
157.00	110.00	79.79	0.00	79.79	0.05
158.00	104.10	130.84	0.00	130.84	0.08
159.00	98.20	208.78	0.00	208.78	0.14
160.00	92.30	324.19	0.00	324.19	0.22
161.00	86.40	489.86	0.00	489.86	0.35
162.00	80.50	720.29	0.00	720.29	0.54
163.00	74.60	1030.64	0.00	1030.64	0.80
164.00	68.70	1435.06	0.00	1435.06	1.18
165.00	62.80	1944.43	0.00	1944.43	1.68
166.00	56.90	2563.76	0.00	2563.76	2.35
167.00	51.00	3289.47	0.00	3289.47	3.21
168.00	45.10	4107.10	0.00	4107.10	4.27
169.00	39.20	4990.07	0.00	4990.07	5.57
170.00	33.30	5899.84	0.00	5899.84	7.11
171.00	27.40	6787.90	0.00	6787.90	8.87
172.00	21.50	7599.64	0.00	7599.64	10.85
173.00	15.60	8279.66	0.00	8279.66	13.00
174.00	9.70	8777.97	0.00	8777.97	15.28
175.00	3.80	9056.02	0.00	9056.02	17.63
176.00	-2.10	9091.66	22.56	9114.22	20.00
177.00	-8.00	8882.00	121.92	9003.92	22.34
178.00	-13.90	8443.84	159.92	8603.76	24.57
179.00	-19.80	7811.45	192.33	8003.78	26.65
180.00	-25.70	7032.10	221.16	7253.25	28.53
181.00	-31.60	6160.28	247.50	6407.77	30.19
182.00	-37.50	5251.43	271.99	5523.42	30.30
183.00	-43.40	4356.29	295.04	4651.33	30.39
184.00	-49.30	3516.56	316.93	3833.49	30.47
185.00	-55.20	2762.37	337.84	3100.21	30.53
186.00	-61.10	2111.58	357.94	2469.52	30.58
187.00	-67.00	1570.71	377.33	1948.03	30.62
188.00	-72.90	1136.96	396.10	1533.05	30.65
189.00	-78.80	800.86	414.32	1215.17	30.67

190.00	-84.70	548.94	432.04	980.99	30.69
191.00	-90.60	366.15	449.33	815.48	30.70
192.00	-96.50	237.66	466.21	703.88	30.72
193.00	-102.40	150.11	482.73	632.84	30.73
194.00	-108.30	92.27	498.90	591.17	30.74
195.00	-114.20	55.19	514.77	569.95	30.75
196.00	-120.10	32.12	530.34	562.46	30.76
197.00	-126.00	18.19	545.65	563.84	30.77
198.00	-131.90	10.03	560.70	570.72	30.78
199.00	-137.80	5.38	575.51	580.89	30.79
200.00	-143.70	2.81	590.10	592.90	30.81
201.00	-149.60	1.43	604.47	605.90	30.82
202.00	-155.50	0.70	618.65	619.35	30.83
203.00	-161.40	0.34	632.63	632.97	30.84
204.00	-167.30	0.16	646.43	646.59	30.85
205.00	-173.20	0.07	660.06	660.14	30.87
206.00	-179.10	0.03	673.53	673.56	30.88
207.00	-185.00	0.01	686.83	686.85	30.89
208.00	-190.90	0.01	699.99	699.99	30.90
209.00	-196.80	0.00	712.99	713.00	30.92
210.00	-202.70	0.00	725.86	725.86	30.93
211.00	-208.60	0.00	738.59	738.59	30.95
212.00	-214.50	0.00	751.19	751.19	30.96
213.00	-220.40	0.00	763.66	763.66	30.98
214.00	-226.30	0.00	776.01	776.01	30.99
215.00	-232.20	0.00	788.24	788.24	31.00
216.00	-238.10	0.00	800.35	800.35	31.02
217.00	-244.00	0.00	812.36	812.36	31.04
218.00	-249.90	0.00	824.25	824.25	31.05
219.00	-255.80	0.00	836.04	836.04	31.07
220.00	-261.70	0.00	847.72	847.72	31.08
221.00	-267.60	0.00	859.31	859.31	31.10
222.00	-273.50	0.00	870.79	870.79	31.12
223.00	-279.40	0.00	873.39	873.39	31.13
224.00	-285.30	0.00	866.80	866.80	31.15
225.00	-291.20	0.00	860.41	860.41	31.17
226.00	-297.10	0.00	854.21	854.21	31.18
227.00	-303.00	0.00	848.20	848.20	31.20
228.00	-308.90	0.00	842.36	842.36	31.22
229.00	-314.80	0.00	836.68	836.68	31.23
230.00	-320.70	0.00	831.17	831.17	31.25
231.00	-326.60	0.00	825.80	825.80	31.26
232.00	-332.50	0.00	820.58	820.58	31.28
233.00	-338.40	0.00	815.50	815.50	31.29
234.00	-344.30	0.00	810.55	810.55	31.31
235.00	-350.20	0.00	805.73	805.73	31.33
236.00	-356.10	0.00	801.02	801.02	31.34
237.00	-362.00	0.00	796.44	796.44	31.36
238.00	-367.90	0.00	791.96	791.96	31.37
239.00	-373.80	0.00	787.60	787.60	31.39
240.00	-379.70	0.00	783.33	783.33	31.40
241.00	-385.60	0.00	779.16	779.16	31.42
242.00	-391.50	0.00	775.09	775.09	31.43

243.00	-397.40	0.00	771.11	771.11	31.44
244.00	-403.30	0.00	767.22	767.22	31.46
245.00	-409.20	0.00	763.41	763.41	31.47
246.00	-415.10	0.00	759.69	759.69	31.49
247.00	-421.00	0.00	756.04	756.04	31.50
248.00	-426.90	0.00	752.47	752.47	31.52
249.00	-432.80	0.00	748.98	748.98	31.53
250.00	-438.70	0.00	745.55	745.55	31.55
251.00	-444.60	0.00	742.20	742.20	31.56
252.00	-450.50	0.00	738.91	738.91	31.57
253.00	-456.40	0.00	735.68	735.68	31.59
254.00	-462.30	0.00	732.52	732.52	31.60
255.00	-468.20	0.00	729.41	729.41	31.62
256.00	-474.10	0.00	726.37	726.37	31.63
257.00	-480.00	0.00	723.38	723.38	31.64
258.00	-485.90	0.00	720.45	720.45	31.66
259.00	-491.80	0.00	717.57	717.57	31.67
260.00	-497.70	0.00	714.74	714.74	31.68
261.00	-503.60	0.00	711.96	711.96	31.70
262.00	-509.50	0.00	709.23	709.23	31.71
263.00	-515.40	0.00	706.55	706.55	31.72
264.00	-521.30	0.00	703.91	703.91	31.74
265.00	-527.20	0.00	701.32	701.32	31.75
266.00	-533.10	0.00	698.77	698.77	31.76
267.00	-539.00	0.00	696.26	696.26	31.78
268.00	-544.90	0.00	693.80	693.80	31.79
269.00	-550.80	0.00	691.37	691.37	31.80
270.00	-556.70	0.00	688.99	688.99	31.82
271.00	-562.60	0.00	686.64	686.64	31.83
272.00	-568.50	0.00	684.32	684.32	31.84
273.00	-574.40	0.00	682.05	682.05	31.86
274.00	-580.30	0.00	679.81	679.81	31.87
275.00	-586.20	0.00	677.60	677.60	31.88
276.00	-592.10	0.00	675.42	675.42	31.89
277.00	-598.00	0.00	673.28	673.28	31.91
278.00	-603.90	0.00	671.17	671.17	31.92
279.00	-609.80	0.00	669.09	669.09	31.93
280.00	-615.70	0.00	667.04	667.04	31.95
281.00	-621.60	0.00	665.02	665.02	31.96
282.00	-627.50	0.00	663.03	663.03	31.97
283.00	-633.40	0.00	661.07	661.07	31.98
284.00	-639.30	0.00	659.13	659.13	32.00
285.00	-645.20	0.00	657.22	657.22	32.01
286.00	-651.10	0.00	655.34	655.34	32.02
287.00	-657.00	0.00	653.48	653.48	32.03
288.00	-662.90	0.00	651.65	651.65	32.04
289.00	-668.80	0.00	649.84	649.84	32.06
290.00	-674.70	0.00	648.05	648.05	32.07
291.00	-680.60	0.00	646.29	646.29	32.08
292.00	-686.50	0.00	644.55	644.55	32.09
293.00	-692.40	0.00	642.84	642.84	32.11
294.00	-698.30	0.00	641.14	641.14	32.12
295.00	-704.20	0.00	639.47	639.47	32.13

296.00	-710.10	0.00	637.82	637.82	32.14
297.00	-716.00	0.00	636.18	636.18	32.15
298.00	-721.90	0.00	634.57	634.57	32.17
299.00	-727.80	0.00	632.98	632.98	32.18
300.00	-733.70	0.00	631.41	631.41	32.19
301.00	-739.60	0.00	629.85	629.85	32.20
302.00	-745.50	0.00	628.32	628.32	32.21
303.00	-751.40	0.00	626.80	626.80	32.23
304.00	-757.30	0.00	625.30	625.30	32.24
305.00	-763.20	0.00	623.82	623.82	32.25
306.00	-769.10	0.00	622.36	622.36	32.26
307.00	-775.00	0.00	620.91	620.91	32.27
308.00	-780.90	0.00	619.48	619.48	32.28
309.00	-786.80	0.00	618.06	618.06	32.30
310.00	-792.70	0.00	616.66	616.66	32.31
311.00	-798.60	0.00	615.28	615.28	32.32
312.00	-804.50	0.00	613.91	613.91	32.33
313.00	-810.40	0.00	612.56	612.56	32.34
314.00	-816.30	0.00	611.22	611.22	32.35
315.00	-822.20	0.00	609.90	609.90	32.36
316.00	-828.10	0.00	608.59	608.59	32.38
317.00	-834.00	0.00	607.29	607.29	32.39
318.00	-839.90	0.00	606.01	606.01	32.40
319.00	-845.80	0.00	604.74	604.74	32.41
320.00	-851.70	0.00	603.48	603.48	32.42
321.00	-857.60	0.00	602.24	602.24	32.43
322.00	-863.50	0.00	601.01	601.01	32.44
323.00	-869.40	0.00	599.80	599.80	32.46
324.00	-875.30	0.00	598.59	598.59	32.47
325.00	-881.20	0.00	597.40	597.40	32.48
326.00	-887.10	0.00	596.22	596.22	32.49
327.00	-893.00	0.00	595.05	595.05	32.50
328.00	-898.90	0.00	593.89	593.89	32.51
329.00	-904.80	0.00	592.75	592.75	32.52
330.00	-910.70	0.00	591.61	591.61	32.53
331.00	-916.60	0.00	590.49	590.49	32.54
332.00	-922.50	0.00	589.37	589.37	32.56
333.00	-928.40	0.00	588.27	588.27	32.57
334.00	-934.30	0.00	587.18	587.18	32.58
335.00	-940.20	0.00	586.10	586.10	32.59
336.00	-946.10	0.00	585.03	585.03	32.60
337.00	-952.00	0.00	583.97	583.97	32.61
338.00	-957.90	0.00	582.91	582.91	32.62
339.00	-963.80	0.00	581.87	581.87	32.63
340.00	-969.70	0.00	580.84	580.84	32.64
341.00	-975.60	0.00	579.82	579.82	32.65
342.00	-981.50	0.00	578.80	578.80	32.67
343.00	-987.40	0.00	577.80	577.80	32.68
344.00	-993.30	0.00	576.80	576.80	32.69
345.00	-999.20	0.00	575.82	575.82	32.70
346.00	-1005.10	0.00	574.84	574.84	32.71
347.00	-1011.00	0.00	573.87	573.87	32.72
348.00	-1016.90	0.00	572.91	572.91	32.73



349.00	-1022.80	0.00	571.96	571.96	32.74
350.00	-1028.70	0.00	571.01	571.01	32.75
351.00	-1034.60	0.00	570.08	570.08	32.76
352.00	-1040.50	0.00	569.15	569.15	32.77
353.00	-1046.40	0.00	568.23	568.23	32.78
354.00	-1052.30	0.00	567.31	567.31	32.79
355.00	-1058.20	0.00	566.41	566.41	32.80
356.00	-1064.10	0.00	565.51	565.51	32.82
357.00	-1070.00	0.00	564.62	564.62	32.83
358.00	-1075.90	0.00	563.74	563.74	32.84
359.00	-1081.80	0.00	562.86	562.86	32.85
360.00	-1087.70	0.00	562.00	562.00	32.86
361.00	-1093.60	0.00	561.13	561.13	32.87
362.00	-1099.50	0.00	560.28	560.28	32.88
363.00	-1105.40	0.00	559.43	559.43	32.89
364.00	-1111.30	0.00	558.59	558.59	32.90
365.00	-1117.20	0.00	557.76	557.76	32.91
366.00	-1123.10	0.00	556.93	556.93	32.92
367.00	-1129.00	0.00	556.11	556.11	32.93
368.00	-1134.90	0.00	555.30	555.30	32.94
369.00	-1140.80	0.00	554.49	554.49	32.95
370.00	-1146.70	0.00	553.69	553.69	32.96
371.00	-1152.60	0.00	552.89	552.89	32.97
372.00	-1158.50	0.00	552.10	552.10	32.98
373.00	-1164.40	0.00	551.32	551.32	32.99
374.00	-1170.30	0.00	550.54	550.54	33.00
375.00	-1176.20	0.00	549.77	549.77	33.01
376.00	-1182.10	0.00	549.00	549.00	33.02
377.00	-1188.00	0.00	548.24	548.24	33.03
378.00	-1193.90	0.00	547.49	547.49	33.04
379.00	-1199.80	0.00	546.74	546.74	33.05
380.00	-1205.70	0.00	545.99	545.99	33.06
381.00	-1211.60	0.00	545.26	545.26	33.07
382.00	-1217.50	0.00	544.52	544.52	33.08
383.00	-1223.40	0.00	543.80	543.80	33.09
384.00	-1229.30	0.00	543.08	543.08	33.10
385.00	-1235.20	0.00	542.36	542.36	33.11
386.00	-1241.10	0.00	541.65	541.65	33.12
387.00	-1247.00	0.00	540.94	540.94	33.14
388.00	-1252.90	0.00	540.24	540.24	33.15
389.00	-1258.80	0.00	539.54	539.54	33.16
390.00	-1264.70	0.00	538.85	538.85	33.17
391.00	-1270.60	0.00	538.16	538.16	33.18
392.00	-1276.50	0.00	537.48	537.48	33.19

Initial flashing fraction = 0.165

Initial flashing mass = 7480.936 kg

Release detected at 152.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 175.644 seconds

Wind speed for max CC concentration is 5.900 m/sec



Meander factor at this wind speed is 1.02

Hor. coeff. adjusted for meander = 35.590 m

Maximum CR concentration at 120.0 seconds after detection 31.84 ppm

50 Ton Sulfur Dioxide Release at HCT; 33 second isolation  
Output file is so2hct33.out

Accident scenario is tank failure

Mass of spill, kg = 45360.00

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Detection at intake

Detection concentration, ppm = 2.40

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 1036.30

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 7.19

Unadjusted horizontal dispersion coef., m = 35.01

Unadjusted vertical dispersion coef., m = 14.27

Horizontal dispersion coefficient, m = 35.74

Vertical dispersion coefficient, m = 15.98

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	1638.00	1.99

1.10	1664.23	2.23
1.20	1673.13	2.42
1.30	2507.24	2.73
1.40	2778.41	3.07
1.50	2932.13	3.47
1.60	2962.90	3.82
1.70	2937.85	4.10
1.80	2665.35	4.43
1.90	2056.26	4.68
2.00	1727.36	4.77
2.10	1538.62	5.33
2.20	1459.09	5.94
2.30	1424.13	6.39
2.40	1402.97	7.05
2.50	1396.23	7.62
2.60	1390.93	8.14
2.70	1378.53	9.33
2.80	1381.23	9.98
2.90	1376.48	10.81
3.00	1371.77	11.93
3.10	1363.48	12.48
3.20	1310.82	13.40
3.30	1267.56	14.85
3.40	1221.44	15.87
3.50	1188.71	16.31
3.60	1147.69	17.57
3.70	1118.67	18.28
3.80	1081.96	20.06
3.90	1051.72	21.39
4.00	1027.22	22.16
4.10	995.82	24.34
4.20	969.95	25.98
4.30	945.33	26.94
4.40	925.41	27.35
4.50	902.91	29.45
4.60	884.75	28.88
4.70	864.10	30.07
4.80	844.35	30.83
4.90	828.47	31.13
5.00	810.25	33.06
5.10	795.63	32.68
5.20	778.77	33.83
5.30	762.59	34.61
5.40	747.03	35.08
5.50	734.59	35.21
5.60	722.59	35.15
5.70	708.57	35.02
5.80	697.42	34.69
5.90	684.32	35.18
6.00	673.93	34.65

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
152.00	200.30	0.00	0.00	0.00	0.00
153.00	194.80	0.00	0.00	0.00	0.00
154.00	189.30	0.01	0.00	0.01	0.00
155.00	183.80	0.02	0.00	0.02	0.00
156.00	178.30	0.04	0.00	0.04	0.00
157.00	172.80	0.08	0.00	0.08	0.00
158.00	167.30	0.16	0.00	0.16	0.00
159.00	161.80	0.32	0.00	0.32	0.00
160.00	156.30	0.64	0.00	0.64	0.00
161.00	150.80	1.24	0.00	1.24	0.00
162.00	145.30	2.34	0.00	2.34	0.00
163.00	139.80	4.33	0.00	4.33	0.00
164.00	134.30	7.81	0.00	7.81	0.00
165.00	128.80	13.76	0.00	13.76	0.01
166.00	123.30	23.68	0.00	23.68	0.01
167.00	117.80	39.79	0.00	39.79	0.02
168.00	112.30	65.31	0.00	65.31	0.04
169.00	106.80	104.69	0.00	104.69	0.07
170.00	101.30	163.88	0.00	163.88	0.11
171.00	95.80	250.52	0.00	250.52	0.18
172.00	90.30	374.02	0.00	374.02	0.27
173.00	84.80	545.31	0.00	545.31	0.42
174.00	79.30	776.45	0.00	776.45	0.62
175.00	73.80	1079.68	0.00	1079.68	0.90
176.00	68.30	1466.18	0.00	1466.18	1.28
177.00	62.80	1944.43	0.00	1944.43	1.79
178.00	57.30	2518.32	0.00	2518.32	2.44
179.00	51.80	3185.24	0.00	3185.24	3.27
180.00	46.30	3934.46	0.00	3934.46	4.29
181.00	40.80	4746.15	0.00	4746.15	5.53
182.00	35.30	5591.28	0.00	5591.28	6.98
183.00	29.80	6432.69	0.00	6432.69	8.65
184.00	24.30	7227.49	0.00	7227.49	10.53
185.00	18.80	7930.40	0.00	7930.40	12.59
186.00	13.30	8497.97	0.00	8497.97	14.80
187.00	7.80	8892.99	0.00	8892.99	17.11
188.00	2.30	9088.53	0.00	9088.53	19.47
189.00	-3.20	9070.93	24.18	9095.11	21.84
190.00	-8.70	8841.44	130.67	8972.10	24.17
191.00	-14.20	8416.02	171.33	8587.35	26.40
192.00	-19.70	7823.54	206.00	8029.54	28.48
193.00	-25.20	7102.52	236.83	7339.34	30.38
194.00	-30.70	6297.01	264.98	6561.99	32.08
195.00	-36.20	5452.17	291.16	5743.32	33.57
196.00	-41.70	4610.17	315.79	4925.95	33.67
197.00	-47.20	3806.95	339.17	4146.12	33.75
198.00	-52.70	3070.08	361.51	3431.59	33.82
199.00	-58.20	2417.88	382.97	2800.86	33.87

200.00	-63.70	1859.66	403.67	2263.33	33.91
201.00	-69.20	1396.83	423.71	1820.54	33.95
202.00	-74.70	1024.63	443.16	1467.79	33.98
203.00	-80.20	734.02	462.08	1196.09	34.00
204.00	-85.70	513.52	480.52	994.04	34.02
205.00	-91.20	350.85	498.54	849.38	34.04
206.00	-96.70	234.09	516.16	750.25	34.05
207.00	-102.20	152.54	533.41	685.95	34.06
208.00	-107.70	97.07	550.34	647.40	34.08
209.00	-113.20	60.32	566.95	627.27	34.09
210.00	-118.70	36.61	583.27	619.88	34.10
211.00	-124.20	21.70	599.32	621.02	34.11
212.00	-129.70	12.56	615.11	627.67	34.12
213.00	-135.20	7.10	630.66	637.76	34.14
214.00	-140.70	3.92	645.99	649.91	34.15
215.00	-146.20	2.11	661.10	663.21	34.16
216.00	-151.70	1.11	676.01	677.12	34.17
217.00	-157.20	0.57	690.72	691.29	34.19
218.00	-162.70	0.29	705.25	705.53	34.20
219.00	-168.20	0.14	719.60	719.74	34.21
220.00	-173.70	0.07	733.77	733.84	34.23
221.00	-179.20	0.03	747.79	747.82	34.24
222.00	-184.70	0.01	761.65	761.66	34.26
223.00	-190.20	0.01	775.36	775.36	34.27
224.00	-195.70	0.00	788.92	788.92	34.28
225.00	-201.20	0.00	802.34	802.35	34.30
226.00	-206.70	0.00	815.63	815.63	34.32
227.00	-212.20	0.00	828.79	828.79	34.33
228.00	-217.70	0.00	841.81	841.81	34.35
229.00	-223.20	0.00	854.72	854.72	34.36
230.00	-228.70	0.00	867.50	867.50	34.38
231.00	-234.20	0.00	880.17	880.17	34.40
232.00	-239.70	0.00	892.73	892.73	34.41
233.00	-245.20	0.00	905.17	905.17	34.43
234.00	-250.70	0.00	917.51	917.51	34.45
235.00	-256.20	0.00	929.74	929.74	34.47
236.00	-261.70	0.00	932.41	932.41	34.48
237.00	-267.20	0.00	925.34	925.34	34.50
238.00	-272.70	0.00	918.48	918.48	34.52
239.00	-278.20	0.00	911.83	911.83	34.54
240.00	-283.70	0.00	905.38	905.38	34.55
241.00	-289.20	0.00	899.12	899.12	34.57
242.00	-294.70	0.00	893.03	893.03	34.59
243.00	-300.20	0.00	887.12	887.12	34.61
244.00	-305.70	0.00	881.36	881.36	34.62
245.00	-311.20	0.00	875.76	875.76	34.64
246.00	-316.70	0.00	870.31	870.31	34.66
247.00	-322.20	0.00	865.00	865.00	34.67
248.00	-327.70	0.00	859.83	859.83	34.69
249.00	-333.20	0.00	854.78	854.78	34.71
250.00	-338.70	0.00	849.86	849.86	34.72
251.00	-344.20	0.00	845.06	845.06	34.74
252.00	-349.70	0.00	840.38	840.38	34.75



253.00	-355.20	0.00	835.80	835.80	34.77
254.00	-360.70	0.00	831.33	831.33	34.79
255.00	-366.20	0.00	826.96	826.96	34.80
256.00	-371.70	0.00	822.69	822.69	34.82
257.00	-377.20	0.00	818.52	818.52	34.83
258.00	-382.70	0.00	814.44	814.44	34.85
259.00	-388.20	0.00	810.44	810.44	34.86
260.00	-393.70	0.00	806.53	806.53	34.88
261.00	-399.20	0.00	802.70	802.70	34.89
262.00	-404.70	0.00	798.95	798.95	34.91
263.00	-410.20	0.00	795.27	795.27	34.92
264.00	-415.70	0.00	791.67	791.67	34.94
265.00	-421.20	0.00	788.15	788.15	34.95
266.00	-426.70	0.00	784.69	784.69	34.97
267.00	-432.20	0.00	781.29	781.29	34.98
268.00	-437.70	0.00	777.96	777.96	35.00
269.00	-443.20	0.00	774.70	774.70	35.01
270.00	-448.70	0.00	771.49	771.49	35.03
271.00	-454.20	0.00	768.35	768.35	35.04
272.00	-459.70	0.00	765.26	765.26	35.06
273.00	-465.20	0.00	762.22	762.22	35.07
274.00	-470.70	0.00	759.24	759.24	35.09
275.00	-476.20	0.00	756.31	756.31	35.10
276.00	-481.70	0.00	753.43	753.43	35.11
277.00	-487.20	0.00	750.61	750.61	35.13
278.00	-492.70	0.00	747.83	747.83	35.14
279.00	-498.20	0.00	745.09	745.09	35.16
280.00	-503.70	0.00	742.40	742.40	35.17
281.00	-509.20	0.00	739.76	739.76	35.18
282.00	-514.70	0.00	737.15	737.15	35.20
283.00	-520.20	0.00	734.59	734.59	35.21
284.00	-525.70	0.00	732.07	732.07	35.23
285.00	-531.20	0.00	729.59	729.59	35.24
286.00	-536.70	0.00	727.15	727.15	35.25
287.00	-542.20	0.00	724.75	724.75	35.27
288.00	-547.70	0.00	722.38	722.38	35.28
289.00	-553.20	0.00	720.05	720.05	35.29
290.00	-558.70	0.00	717.75	717.75	35.31
291.00	-564.20	0.00	715.48	715.48	35.32
292.00	-569.70	0.00	713.25	713.25	35.34
293.00	-575.20	0.00	711.05	711.05	35.35
294.00	-580.70	0.00	708.89	708.89	35.36
295.00	-586.20	0.00	706.75	706.75	35.38
296.00	-591.70	0.00	704.64	704.64	35.39
297.00	-597.20	0.00	702.57	702.57	35.40
298.00	-602.70	0.00	700.52	700.52	35.42
299.00	-608.20	0.00	698.50	698.50	35.43
300.00	-613.70	0.00	696.50	696.50	35.44
301.00	-619.20	0.00	694.54	694.54	35.45
302.00	-624.70	0.00	692.60	692.60	35.47
303.00	-630.20	0.00	690.68	690.68	35.48
304.00	-635.70	0.00	688.79	688.79	35.49
305.00	-641.20	0.00	686.93	686.93	35.51

306.00	-646.70	0.00	685.09	685.09	35.52
307.00	-652.20	0.00	683.27	683.27	35.53
308.00	-657.70	0.00	681.48	681.48	35.55
309.00	-663.20	0.00	679.70	679.70	35.56
310.00	-668.70	0.00	677.95	677.95	35.57
311.00	-674.20	0.00	676.22	676.22	35.58
312.00	-679.70	0.00	674.52	674.52	35.60
313.00	-685.20	0.00	672.83	672.83	35.61
314.00	-690.70	0.00	671.16	671.16	35.62
315.00	-696.20	0.00	669.52	669.52	35.63
316.00	-701.70	0.00	667.89	667.89	35.65
317.00	-707.20	0.00	666.28	666.28	35.66
318.00	-712.70	0.00	664.69	664.69	35.67
319.00	-718.20	0.00	663.12	663.12	35.68
320.00	-723.70	0.00	661.57	661.57	35.70
321.00	-729.20	0.00	660.03	660.03	35.71
322.00	-734.70	0.00	658.51	658.51	35.72
323.00	-740.20	0.00	657.01	657.01	35.73
324.00	-745.70	0.00	655.53	655.53	35.75
325.00	-751.20	0.00	654.06	654.06	35.76
326.00	-756.70	0.00	652.61	652.61	35.77
327.00	-762.20	0.00	651.17	651.17	35.78
328.00	-767.70	0.00	649.75	649.75	35.80
329.00	-773.20	0.00	648.35	648.35	35.81
330.00	-778.70	0.00	646.96	646.96	35.82
331.00	-784.20	0.00	645.58	645.58	35.83
332.00	-789.70	0.00	644.22	644.22	35.84
333.00	-795.20	0.00	642.88	642.88	35.86
334.00	-800.70	0.00	641.54	641.54	35.87
335.00	-806.20	0.00	640.22	640.22	35.88
336.00	-811.70	0.00	638.92	638.92	35.89
337.00	-817.20	0.00	637.63	637.63	35.90
338.00	-822.70	0.00	636.35	636.35	35.92
339.00	-828.20	0.00	635.08	635.08	35.93
340.00	-833.70	0.00	633.83	633.83	35.94
341.00	-839.20	0.00	632.58	632.58	35.95
342.00	-844.70	0.00	631.35	631.35	35.96
343.00	-850.20	0.00	630.14	630.14	35.97
344.00	-855.70	0.00	628.93	628.93	35.99
345.00	-861.20	0.00	627.74	627.74	36.00
346.00	-866.70	0.00	626.56	626.56	36.01
347.00	-872.20	0.00	625.38	625.38	36.02
348.00	-877.70	0.00	624.22	624.22	36.03
349.00	-883.20	0.00	623.07	623.07	36.05
350.00	-888.70	0.00	621.94	621.94	36.06
351.00	-894.20	0.00	620.81	620.81	36.07
352.00	-899.70	0.00	619.69	619.69	36.08
353.00	-905.20	0.00	618.58	618.58	36.09
354.00	-910.70	0.00	617.49	617.49	36.10
355.00	-916.20	0.00	616.40	616.40	36.11
356.00	-921.70	0.00	615.32	615.32	36.13
357.00	-927.20	0.00	614.25	614.25	36.14
358.00	-932.70	0.00	613.19	613.19	36.15



359.00	-938.20	0.00	612.15	612.15	36.16
360.00	-943.70	0.00	611.11	611.11	36.17
361.00	-949.20	0.00	610.07	610.07	36.18
362.00	-954.70	0.00	609.05	609.05	36.19
363.00	-960.20	0.00	608.04	608.04	36.21
364.00	-965.70	0.00	607.04	607.04	36.22
365.00	-971.20	0.00	606.04	606.04	36.23
366.00	-976.70	0.00	605.05	605.05	36.24
367.00	-982.20	0.00	604.07	604.07	36.25
368.00	-987.70	0.00	603.10	603.10	36.26
369.00	-993.20	0.00	602.14	602.14	36.27
370.00	-998.70	0.00	601.19	601.19	36.29
371.00	-1004.20	0.00	600.24	600.24	36.30
372.00	-1009.70	0.00	599.30	599.30	36.31
373.00	-1015.20	0.00	598.37	598.37	36.32
374.00	-1020.70	0.00	597.44	597.44	36.33
375.00	-1026.20	0.00	596.53	596.53	36.34
376.00	-1031.70	0.00	595.62	595.62	36.35
377.00	-1037.20	0.00	594.72	594.72	36.36
378.00	-1042.70	0.00	593.82	593.82	36.37
379.00	-1048.20	0.00	592.94	592.94	36.39
380.00	-1053.70	0.00	592.05	592.05	36.40
381.00	-1059.20	0.00	591.18	591.18	36.41
382.00	-1064.70	0.00	590.31	590.31	36.42
383.00	-1070.20	0.00	589.45	589.45	36.43
384.00	-1075.70	0.00	588.60	588.60	36.44
385.00	-1081.20	0.00	587.75	587.75	36.45
386.00	-1086.70	0.00	586.91	586.91	36.46
387.00	-1092.20	0.00	586.08	586.08	36.47
388.00	-1097.70	0.00	585.25	585.25	36.48
389.00	-1103.20	0.00	584.43	584.43	36.49
390.00	-1108.70	0.00	583.61	583.61	36.51
391.00	-1114.20	0.00	582.81	582.81	36.52
392.00	-1119.70	0.00	582.00	582.00	36.53
393.00	-1125.20	0.00	581.20	581.20	36.54
394.00	-1130.70	0.00	580.41	580.41	36.55
395.00	-1136.20	0.00	579.63	579.63	36.56
396.00	-1141.70	0.00	578.85	578.85	36.57
397.00	-1147.20	0.00	578.07	578.07	36.58
398.00	-1152.70	0.00	577.30	577.30	36.59
399.00	-1158.20	0.00	576.54	576.54	36.60
400.00	-1163.70	0.00	575.78	575.78	36.61
401.00	-1169.20	0.00	575.03	575.03	36.62
402.00	-1174.70	0.00	574.28	574.28	36.63
403.00	-1180.20	0.00	573.54	573.54	36.65

Initial flashing fraction = 0.165

Initial flashing mass = 7480.936 kg

Release detected at 163.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 188.418 seconds



Wind speed for max CC concentration is 5.500 m/sec

Meander factor at this wind speed is 1.12

Hor. coeff. adjusted for meander = 38.204 m

Maximum CR concentration at 120.0 seconds after detection 35.21 ppm

4.5 Ton SO<sub>2</sub> Release at CR 1/2 with 30 second isolation  
Output file is so2cr130.out

Accident scenario is tank failure

Mass of spill, kg = 4082.40

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Detection at intake

Detection concentration, ppm = 2.40

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 228.60

Building wake factor = 3.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 55.75

Dispersion coeff for initial flashing, m = 3.22

Unadjusted horizontal dispersion coef., m = 8.74

Unadjusted vertical dispersion coef., m = 4.55

Horizontal dispersion coefficient, m = 9.32

Vertical dispersion coefficient, m = 5.57

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	488.06	16.94



1.10	437.37	18.81
1.20	398.80	19.44
1.30	364.78	20.82
1.40	337.07	22.56
1.50	313.12	24.00
1.60	292.20	25.05
1.70	274.77	25.72
1.80	259.27	26.50
1.90	245.41	26.35
2.00	232.93	26.00
2.10	234.95	27.97
2.20	237.62	29.28
2.30	240.99	30.37
2.40	242.77	31.39
2.50	232.84	32.28
2.60	223.68	33.13
2.70	215.20	33.90
2.80	207.98	34.55
2.90	200.62	35.12
3.00	194.36	35.46
3.10	187.91	35.81
3.20	182.43	35.88
3.30	177.27	35.65
3.40	172.41	34.91
3.50	167.32	33.99
3.60	163.00	33.05
3.70	158.43	32.23
3.80	155.03	31.31
3.90	150.90	30.58
4.00	147.41	29.81
4.10	143.66	29.15
4.20	140.50	28.46
4.30	137.49	27.80
4.40	134.23	27.23
4.50	131.48	26.62
4.60	128.86	26.04
4.70	126.34	25.49
4.80	123.93	24.96
4.90	121.61	24.45
5.00	119.38	23.97
5.10	116.91	23.55
5.20	114.86	23.10
5.30	113.20	22.61
5.40	110.98	22.24
5.50	109.14	21.84
5.60	107.37	21.45
5.70	105.66	21.07
5.80	104.00	20.71
5.90	102.12	20.40
6.00	100.86	20.02

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
55.00	52.60	0.00	0.00	0.00	0.00
56.00	49.40	0.01	0.00	0.01	0.00
57.00	46.20	0.08	0.00	0.08	0.00
58.00	43.00	0.43	0.00	0.43	0.00
59.00	39.80	1.99	0.00	1.99	0.00
60.00	36.60	8.15	0.00	8.15	0.00
61.00	33.40	29.60	0.00	29.60	0.01
62.00	30.20	95.56	0.00	95.56	0.04
63.00	27.00	274.18	0.00	274.18	0.11
64.00	23.80	699.21	0.00	699.21	0.29
65.00	20.60	1584.73	0.00	1584.73	0.70
66.00	17.40	3192.11	0.00	3192.11	1.53
67.00	14.20	5714.55	0.00	5714.55	3.02
68.00	11.00	9092.10	0.00	9092.10	5.38
69.00	7.80	12856.58	0.00	12856.58	8.73
70.00	4.60	15632.73	0.00	15632.73	12.80
71.00	1.40	16039.88	0.00	16039.88	16.97
72.00	-1.80	16012.41	60.84	16073.25	21.15
73.00	-5.00	15552.55	461.10	16013.65	25.31
74.00	-8.20	12391.36	620.76	13012.12	28.69
75.00	-11.40	8634.85	752.97	9387.83	31.13
76.00	-14.60	5347.74	688.78	6036.52	32.69
77.00	-17.80	2943.50	622.59	3566.09	33.61
78.00	-21.00	1439.92	573.72	2013.64	34.13
79.00	-24.20	626.02	535.74	1161.77	34.42
80.00	-27.40	241.89	505.13	747.02	34.60
81.00	-30.60	83.07	479.77	562.84	34.74
82.00	-33.80	25.35	458.32	483.67	34.86
83.00	-37.00	6.88	439.87	446.74	34.97
84.00	-40.20	1.66	423.77	425.43	35.07
85.00	-43.40	0.36	409.57	409.92	35.17
86.00	-46.60	0.07	396.92	396.98	35.26
87.00	-49.80	0.01	385.55	385.56	35.35
88.00	-53.00	0.00	375.27	375.27	35.44
89.00	-56.20	0.00	365.91	365.91	35.53
90.00	-59.40	0.00	357.34	357.34	35.53
91.00	-62.60	0.00	349.46	349.46	35.54
92.00	-65.80	0.00	342.17	342.17	35.54
93.00	-69.00	0.00	335.41	335.41	35.55
94.00	-72.20	0.00	329.12	329.12	35.56
95.00	-75.40	0.00	323.24	323.24	35.56
96.00	-78.60	0.00	317.74	317.74	35.57
97.00	-81.80	0.00	312.57	312.57	35.57
98.00	-85.00	0.00	307.70	307.70	35.58
99.00	-88.20	0.00	303.10	303.10	35.58
100.00	-91.40	0.00	298.75	298.75	35.59
101.00	-94.60	0.00	294.63	294.63	35.59
102.00	-97.80	0.00	290.71	290.71	35.60



103.00	-101.00	0.00	286.99	286.99	35.60
104.00	-104.20	0.00	283.44	283.44	35.61
105.00	-107.40	0.00	280.06	280.06	35.61
106.00	-110.60	0.00	276.82	276.82	35.62
107.00	-113.80	0.00	273.73	273.73	35.62
108.00	-117.00	0.00	270.76	270.76	35.63
109.00	-120.20	0.00	267.92	267.92	35.63
110.00	-123.40	0.00	265.19	265.19	35.64
111.00	-126.60	0.00	262.56	262.56	35.64
112.00	-129.80	0.00	260.04	260.04	35.65
113.00	-133.00	0.00	257.61	257.61	35.65
114.00	-136.20	0.00	255.26	255.26	35.65
115.00	-139.40	0.00	253.00	253.00	35.66
116.00	-142.60	0.00	250.81	250.81	35.66
117.00	-145.80	0.00	248.70	248.70	35.67
118.00	-149.00	0.00	246.66	246.66	35.67
119.00	-152.20	0.00	244.68	244.68	35.68
120.00	-155.40	0.00	242.76	242.76	35.68
121.00	-158.60	0.00	240.91	240.91	35.68
122.00	-161.80	0.00	239.11	239.11	35.69
123.00	-165.00	0.00	237.36	237.36	35.69
124.00	-168.20	0.00	235.66	235.66	35.70
125.00	-171.40	0.00	234.01	234.01	35.70
126.00	-174.60	0.00	232.41	232.41	35.70
127.00	-177.80	0.00	230.85	230.85	35.71
128.00	-181.00	0.00	229.34	229.34	35.71
129.00	-184.20	0.00	227.86	227.86	35.72
130.00	-187.40	0.00	226.42	226.42	35.72
131.00	-190.60	0.00	225.02	225.02	35.72
132.00	-193.80	0.00	223.65	223.65	35.73
133.00	-197.00	0.00	222.32	222.32	35.73
134.00	-200.20	0.00	221.02	221.02	35.73
135.00	-203.40	0.00	219.75	219.75	35.74
136.00	-206.60	0.00	218.51	218.51	35.74
137.00	-209.80	0.00	217.30	217.30	35.74
138.00	-213.00	0.00	216.12	216.12	35.75
139.00	-216.20	0.00	214.96	214.96	35.75
140.00	-219.40	0.00	213.83	213.83	35.76
141.00	-222.60	0.00	212.73	212.73	35.76
142.00	-225.80	0.00	211.64	211.64	35.76
143.00	-229.00	0.00	210.58	210.58	35.77
144.00	-232.20	0.00	209.55	209.55	35.77
145.00	-235.40	0.00	208.53	208.53	35.77
146.00	-238.60	0.00	207.54	207.54	35.78
147.00	-241.80	0.00	206.56	206.56	35.78
148.00	-245.00	0.00	205.60	205.60	35.78
149.00	-248.20	0.00	204.67	204.67	35.79
150.00	-251.40	0.00	203.75	203.75	35.79
151.00	-254.60	0.00	202.85	202.85	35.79
152.00	-257.80	0.00	201.96	201.96	35.80
153.00	-261.00	0.00	201.09	201.09	35.80
154.00	-264.20	0.00	200.24	200.24	35.80
155.00	-267.40	0.00	199.41	199.41	35.81

156.00	-270.60	0.00	198.58	198.58	35.81
157.00	-273.80	0.00	197.78	197.78	35.81
158.00	-277.00	0.00	196.98	196.98	35.82
159.00	-280.20	0.00	196.20	196.20	35.82
160.00	-283.40	0.00	195.44	195.44	35.82
161.00	-286.60	0.00	194.68	194.68	35.83
162.00	-289.80	0.00	193.94	193.94	35.83
163.00	-293.00	0.00	193.22	193.22	35.83
164.00	-296.20	0.00	192.50	192.50	35.83
165.00	-299.40	0.00	191.79	191.79	35.84
166.00	-302.60	0.00	191.10	191.10	35.84
167.00	-305.80	0.00	190.42	190.42	35.84
168.00	-309.00	0.00	189.75	189.75	35.85
169.00	-312.20	0.00	189.08	189.08	35.85
170.00	-315.40	0.00	188.43	188.43	35.85
171.00	-318.60	0.00	187.79	187.79	35.86
172.00	-321.80	0.00	187.16	187.16	35.86
173.00	-325.00	0.00	186.54	186.54	35.86
174.00	-328.20	0.00	185.92	185.92	35.87
175.00	-331.40	0.00	185.32	185.32	35.87
176.00	-334.60	0.00	184.73	184.73	35.87
177.00	-337.80	0.00	184.14	184.14	35.87
178.00	-341.00	0.00	183.56	183.56	35.88
179.00	-344.20	0.00	182.99	182.99	35.88
180.00	-347.40	0.00	182.43	182.43	35.88
181.00	-350.60	0.00	181.87	181.87	35.89
182.00	-353.80	0.00	181.32	181.32	35.89
183.00	-357.00	0.00	180.78	180.78	35.89
184.00	-360.20	0.00	180.25	180.25	35.89
185.00	-363.40	0.00	179.73	179.73	35.90
186.00	-366.60	0.00	179.21	179.21	35.90
187.00	-369.80	0.00	178.70	178.70	35.90
188.00	-373.00	0.00	178.19	178.19	35.91
189.00	-376.20	0.00	177.69	177.69	35.91
190.00	-379.40	0.00	177.20	177.20	35.91
191.00	-382.60	0.00	176.71	176.71	35.91
192.00	-385.80	0.00	176.23	176.23	35.92
193.00	-389.00	0.00	175.76	175.76	35.92
194.00	-392.20	0.00	175.29	175.29	35.92
195.00	-395.40	0.00	174.83	174.83	35.93
196.00	-398.60	0.00	174.37	174.37	35.93
197.00	-401.80	0.00	173.92	173.92	35.93
198.00	-405.00	0.00	173.48	173.48	35.93
199.00	-408.20	0.00	173.03	173.03	35.94
200.00	-411.40	0.00	172.60	172.60	35.94
201.00	-414.60	0.00	172.17	172.17	35.94
202.00	-417.80	0.00	171.74	171.74	35.94
203.00	-421.00	0.00	171.32	171.32	35.95
204.00	-424.20	0.00	170.91	170.91	35.95
205.00	-427.40	0.00	170.50	170.50	35.95
206.00	-430.60	0.00	170.09	170.09	35.95
207.00	-433.80	0.00	169.69	169.69	35.96
208.00	-437.00	0.00	169.29	169.29	35.96

209.00	-440.20	0.00	168.90	168.90	35.96
210.00	-443.40	0.00	168.51	168.51	35.97
211.00	-446.60	0.00	168.12	168.12	35.97
212.00	-449.80	0.00	167.74	167.74	35.97
213.00	-453.00	0.00	167.37	167.37	35.97
214.00	-456.20	0.00	166.99	166.99	35.98
215.00	-459.40	0.00	166.62	166.62	35.98
216.00	-462.60	0.00	166.26	166.26	35.98
217.00	-465.80	0.00	165.90	165.90	35.98
218.00	-469.00	0.00	165.54	165.54	35.99
219.00	-472.20	0.00	165.19	165.19	35.99
220.00	-475.40	0.00	164.84	164.84	35.99
221.00	-478.60	0.00	164.49	164.49	35.99
222.00	-481.80	0.00	164.15	164.15	36.00
223.00	-485.00	0.00	163.81	163.81	36.00
224.00	-488.20	0.00	163.47	163.47	36.00
225.00	-491.40	0.00	163.14	163.14	36.00
226.00	-494.60	0.00	162.81	162.81	36.01
227.00	-497.80	0.00	162.48	162.48	36.01
228.00	-501.00	0.00	162.16	162.16	36.01
229.00	-504.20	0.00	161.84	161.84	36.01
230.00	-507.40	0.00	161.52	161.52	36.02
231.00	-510.60	0.00	161.21	161.21	36.02
232.00	-513.80	0.00	160.90	160.90	36.02
233.00	-517.00	0.00	160.59	160.59	36.02
234.00	-520.20	0.00	160.28	160.28	36.03
235.00	-523.40	0.00	159.98	159.98	36.03
236.00	-526.60	0.00	159.68	159.68	36.03
237.00	-529.80	0.00	159.38	159.38	36.03
238.00	-533.00	0.00	159.09	159.09	36.04
239.00	-536.20	0.00	158.80	158.80	36.04
240.00	-539.40	0.00	158.51	158.51	36.04
241.00	-542.60	0.00	158.22	158.22	36.04
242.00	-545.80	0.00	157.94	157.94	36.05
243.00	-549.00	0.00	157.65	157.65	36.05
244.00	-552.20	0.00	157.38	157.38	36.05
245.00	-555.40	0.00	157.10	157.10	36.05
246.00	-558.60	0.00	156.82	156.82	36.06
247.00	-561.80	0.00	156.55	156.55	36.06
248.00	-565.00	0.00	156.28	156.28	36.06
249.00	-568.20	0.00	156.02	156.02	36.06
250.00	-571.40	0.00	155.75	155.75	36.07
251.00	-574.60	0.00	155.49	155.49	36.07
252.00	-577.80	0.00	155.23	155.23	36.07
253.00	-581.00	0.00	154.97	154.97	36.07
254.00	-584.20	0.00	154.71	154.71	36.07
255.00	-587.40	0.00	154.46	154.46	36.08
256.00	-590.60	0.00	154.21	154.21	36.08
257.00	-593.80	0.00	153.95	153.95	36.08
258.00	-597.00	0.00	153.71	153.71	36.08
259.00	-600.20	0.00	153.46	153.46	36.09
260.00	-603.40	0.00	153.22	153.22	36.09
261.00	-606.60	0.00	152.97	152.97	36.09

262.00	-609.80	0.00	152.73	152.73	36.09
263.00	-613.00	0.00	152.50	152.50	36.10
264.00	-616.20	0.00	152.26	152.26	36.10
265.00	-619.40	0.00	152.02	152.02	36.10
266.00	-622.60	0.00	151.79	151.79	36.10
267.00	-625.80	0.00	151.56	151.56	36.10
268.00	-629.00	0.00	151.33	151.33	36.11
269.00	-632.20	0.00	151.10	151.10	36.11
270.00	-635.40	0.00	150.88	150.88	36.11
271.00	-638.60	0.00	150.65	150.65	36.11
272.00	-641.80	0.00	150.43	150.43	36.12
273.00	-645.00	0.00	150.21	150.21	36.12
274.00	-648.20	0.00	149.99	149.99	36.12
275.00	-651.40	0.00	149.77	149.77	36.12
276.00	-654.60	0.00	149.56	149.56	36.13
277.00	-657.80	0.00	149.34	149.34	36.13
278.00	-661.00	0.00	149.13	149.13	36.13
279.00	-664.20	0.00	148.92	148.92	36.13
280.00	-667.40	0.00	148.71	148.71	36.13
281.00	-670.60	0.00	148.50	148.50	36.14
282.00	-673.80	0.00	148.29	148.29	36.14
283.00	-677.00	0.00	148.09	148.09	36.14
284.00	-680.20	0.00	147.88	147.88	36.14
285.00	-683.40	0.00	147.68	147.68	36.15
286.00	-686.60	0.00	147.48	147.48	36.15
287.00	-689.80	0.00	147.28	147.28	36.15
288.00	-693.00	0.00	147.08	147.08	36.15
289.00	-696.20	0.00	146.89	146.89	36.15
290.00	-699.40	0.00	146.69	146.69	36.16
291.00	-702.60	0.00	146.50	146.50	36.16
292.00	-705.80	0.00	146.30	146.30	36.16
293.00	-709.00	0.00	146.11	146.11	36.16
294.00	-712.20	0.00	145.92	145.92	36.17
295.00	-715.40	0.00	145.73	145.73	36.17
296.00	-718.60	0.00	145.54	145.54	36.17
297.00	-721.80	0.00	145.36	145.36	36.17
298.00	-725.00	0.00	145.17	145.17	36.17
299.00	-728.20	0.00	144.99	144.99	36.18
300.00	-731.40	0.00	144.81	144.81	36.18

Initial flashing fraction = 0.165

Initial flashing mass = 673.284 kg

Release detected at 60.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 71.438 seconds

Wind speed for max CC concentration is 3.200 m/sec

Meander factor at this wind speed is 2.21

Hor. coeff. adjusted for meander = 19.323 m

Maximum CR concentration at 120.0 seconds after detection 35.88 ppm



30 Ton SO<sub>2</sub> Valve Release at CR 1/2 with 30 second isolation  
Output file is so2cr230.out

Accident scenario is valve failure

Mass of spill, kg = 0.00

Mass available for leakage, kg = 27216.00

Valve vapor leakage rate, kg/s = 2.53

Valve liquid leakage rate, kg/s = 12.83

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed

assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Detection at intake

Detection concentration, ppm = 2.40

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 6.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 228.60

Building wake factor = 3.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 55.75

Dispersion coeff for initial flashing, m = 0.00

Unadjusted horizontal dispersion coef., m = 8.74

Unadjusted vertical dispersion coef., m = 4.55

Horizontal dispersion coefficient, m = 8.74

Vertical dispersion coefficient, m = 4.55

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	2917.18	22.37

1.10	2654.91	20.35
1.20	2436.25	18.66
1.30	2251.15	17.23
1.40	2092.42	16.00
1.50	1954.81	14.94
1.60	1834.35	14.01
1.70	1728.02	13.19
1.80	1630.73	12.39
1.90	1548.85	11.81
2.00	1472.66	11.22
2.10	1493.02	11.37
2.20	1512.56	11.51
2.30	1531.50	11.65
2.40	1549.89	11.78
2.50	1567.77	11.91
2.60	1517.63	11.52
2.70	1462.51	11.10
2.80	1411.31	10.70
2.90	1363.63	10.34
3.00	1319.12	9.99
3.10	1277.46	9.67
3.20	1238.40	9.37
3.30	1201.69	9.09
3.40	1167.14	8.83
3.50	1134.55	8.58
3.60	1103.76	8.34
3.70	1074.63	8.12
3.80	1047.02	7.90
3.90	1020.82	7.70
4.00	995.93	7.51
4.10	972.24	7.33
4.20	949.68	7.16
4.30	928.16	6.99
4.40	907.61	6.83
4.50	887.97	6.68
4.60	869.18	6.54
4.70	851.18	6.40
4.80	833.93	6.27
4.90	817.39	6.14
5.00	801.49	6.02
5.10	786.22	5.90
5.20	771.53	5.79
5.30	757.40	5.68
5.40	743.78	5.58
5.50	730.66	5.48
5.60	718.00	5.38
5.70	705.78	5.29
5.80	693.98	5.20
5.90	682.58	5.11
6.00	671.56	5.02

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
229.00	-0.40	0.00	2046.94	2046.94	0.53
230.00	-1.40	0.00	2111.04	2111.04	1.08
231.00	-2.40	0.00	2120.63	2120.63	1.63
232.00	-3.40	0.00	2134.46	2134.46	2.19
233.00	-4.40	0.00	2148.46	2148.46	2.75
234.00	-5.40	0.00	2162.03	2162.03	3.31
235.00	-6.40	0.00	2175.04	2175.04	3.88
236.00	-7.40	0.00	2187.53	2187.53	4.44
237.00	-8.40	0.00	2199.54	2199.54	5.01
238.00	-9.40	0.00	2211.11	2211.11	5.59
239.00	-10.40	0.00	2222.30	2222.30	6.17
240.00	-11.40	0.00	2233.14	2233.14	6.75
241.00	-12.40	0.00	2243.67	2243.67	7.33
242.00	-13.40	0.00	2253.92	2253.92	7.91
243.00	-14.40	0.00	2263.91	2263.91	8.50
244.00	-15.40	0.00	2273.66	2273.66	9.09
245.00	-16.40	0.00	2283.20	2283.20	9.68
246.00	-17.40	0.00	2292.53	2292.53	10.28
247.00	-18.40	0.00	2301.68	2301.68	10.87
248.00	-19.40	0.00	2310.66	2310.66	11.47
249.00	-20.40	0.00	2319.48	2319.48	12.07
250.00	-21.40	0.00	2328.14	2328.14	12.67
251.00	-22.40	0.00	2336.67	2336.67	13.28
252.00	-23.40	0.00	2345.06	2345.06	13.89
253.00	-24.40	0.00	2353.33	2353.33	14.50
254.00	-25.40	0.00	2361.48	2361.48	15.11
255.00	-26.40	0.00	2369.51	2369.51	15.72
256.00	-27.40	0.00	2377.44	2377.44	16.33
257.00	-28.40	0.00	2385.27	2385.27	16.95
258.00	-29.40	0.00	2393.01	2393.01	17.57
259.00	-30.40	0.00	2400.65	2400.65	17.62
260.00	-31.40	0.00	2408.20	2408.20	17.66
261.00	-32.40	0.00	2415.67	2415.67	17.71
262.00	-33.40	0.00	2423.06	2423.06	17.76
263.00	-34.40	0.00	2430.37	2430.37	17.81
264.00	-35.40	0.00	2437.61	2437.61	17.86
265.00	-36.40	0.00	2444.78	2444.78	17.90
266.00	-37.40	0.00	2451.88	2451.88	17.95
267.00	-38.40	0.00	2458.91	2458.91	18.00
268.00	-39.40	0.00	2465.88	2465.88	18.05
269.00	-40.40	0.00	2472.79	2472.79	18.10
270.00	-41.40	0.00	2479.64	2479.64	18.15
271.00	-42.40	0.00	2486.43	2486.43	18.20
272.00	-43.40	0.00	2493.17	2493.17	18.24
273.00	-44.40	0.00	2499.86	2499.86	18.29
274.00	-45.40	0.00	2506.49	2506.49	18.34
275.00	-46.40	0.00	2513.07	2513.07	18.39
276.00	-47.40	0.00	2519.60	2519.60	18.44

277.00	-48.40	0.00	2526.09	2526.09	18.49
278.00	-49.40	0.00	2532.53	2532.53	18.54
279.00	-50.40	0.00	2538.92	2538.92	18.59
280.00	-51.40	0.00	2545.27	2545.27	18.64
281.00	-52.40	0.00	2551.58	2551.58	18.69
282.00	-53.40	0.00	2557.85	2557.85	18.74
283.00	-54.40	0.00	2564.08	2564.08	18.79
284.00	-55.40	0.00	2570.27	2570.27	18.84
285.00	-56.40	0.00	2576.42	2576.42	18.90
286.00	-57.40	0.00	2582.53	2582.53	18.95
287.00	-58.40	0.00	2588.61	2588.61	19.00
288.00	-59.40	0.00	2594.65	2594.65	19.05
289.00	-60.40	0.00	2600.66	2600.66	19.10
290.00	-61.40	0.00	2606.63	2606.63	19.15
291.00	-62.40	0.00	2612.58	2612.58	19.20
292.00	-63.40	0.00	2618.48	2618.48	19.25
293.00	-64.40	0.00	2624.36	2624.36	19.31
294.00	-65.40	0.00	2630.21	2630.21	19.36
295.00	-66.40	0.00	2636.02	2636.02	19.41
296.00	-67.40	0.00	2641.81	2641.81	19.46
297.00	-68.40	0.00	2647.57	2647.57	19.51
298.00	-69.40	0.00	2653.29	2653.29	19.57
299.00	-70.40	0.00	2659.00	2659.00	19.62
300.00	-71.40	0.00	2664.67	2664.67	19.67
301.00	-72.40	0.00	2670.32	2670.32	19.72
302.00	-73.40	0.00	2675.94	2675.94	19.78
303.00	-74.40	0.00	2681.53	2681.53	19.83
304.00	-75.40	0.00	2687.10	2687.10	19.88
305.00	-76.40	0.00	2692.65	2692.65	19.94
306.00	-77.40	0.00	2698.17	2698.17	19.99
307.00	-78.40	0.00	2703.66	2703.66	20.04
308.00	-79.40	0.00	2709.14	2709.14	20.10
309.00	-80.40	0.00	2714.59	2714.59	20.15
310.00	-81.40	0.00	2720.01	2720.01	20.20
311.00	-82.40	0.00	2725.42	2725.42	20.26
312.00	-83.40	0.00	2730.80	2730.80	20.31
313.00	-84.40	0.00	2736.16	2736.16	20.36
314.00	-85.40	0.00	2741.50	2741.50	20.42
315.00	-86.40	0.00	2746.82	2746.82	20.47
316.00	-87.40	0.00	2752.12	2752.12	20.53
317.00	-88.40	0.00	2757.40	2757.40	20.58
318.00	-89.40	0.00	2762.66	2762.66	20.64
319.00	-90.40	0.00	2767.90	2767.90	20.69
320.00	-91.40	0.00	2773.12	2773.12	20.75
321.00	-92.40	0.00	2778.32	2778.32	20.80
322.00	-93.40	0.00	2783.50	2783.50	20.86
323.00	-94.40	0.00	2788.66	2788.66	20.91
324.00	-95.40	0.00	2793.81	2793.81	20.97
325.00	-96.40	0.00	2798.93	2798.93	21.02
326.00	-97.40	0.00	2804.04	2804.04	21.08
327.00	-98.40	0.00	2809.14	2809.14	21.13
328.00	-99.40	0.00	2814.21	2814.21	21.19
329.00	-100.40	0.00	2819.27	2819.27	21.24



330.00	-101.40	0.00	2824.31	2824.31	21.30
331.00	-102.40	0.00	2829.33	2829.33	21.35
332.00	-103.40	0.00	2834.34	2834.34	21.41
333.00	-104.40	0.00	2839.33	2839.33	21.47
334.00	-105.40	0.00	2844.31	2844.31	21.52
335.00	-106.40	0.00	2849.27	2849.27	21.58
336.00	-107.40	0.00	2854.22	2854.22	21.63
337.00	-108.40	0.00	2859.15	2859.15	21.69
338.00	-109.40	0.00	2864.06	2864.06	21.75
339.00	-110.40	0.00	2868.96	2868.96	21.80
340.00	-111.40	0.00	2873.85	2873.85	21.86
341.00	-112.40	0.00	2878.72	2878.72	21.92
342.00	-113.40	0.00	2883.57	2883.57	21.97
343.00	-114.40	0.00	2888.42	2888.42	22.03
344.00	-115.40	0.00	2893.25	2893.25	22.09
345.00	-116.40	0.00	2898.06	2898.06	22.14
346.00	-117.40	0.00	2902.86	2902.86	22.20
347.00	-118.40	0.00	2907.65	2907.65	22.26
348.00	-119.40	0.00	2912.42	2912.42	22.32
349.00	-120.40	0.00	2917.18	2917.18	22.37
350.00	-121.40	0.00	2921.93	2921.93	22.43
351.00	-122.40	0.00	2926.66	2926.66	22.49
352.00	-123.40	0.00	2931.39	2931.39	22.55
353.00	-124.40	0.00	2936.10	2936.10	22.61
354.00	-125.40	0.00	2940.79	2940.79	22.66
355.00	-126.40	0.00	2945.48	2945.48	22.72
356.00	-127.40	0.00	2950.15	2950.15	22.78
357.00	-128.40	0.00	2954.81	2954.81	22.84
358.00	-129.40	0.00	2959.46	2959.46	22.90
359.00	-130.40	0.00	2964.09	2964.09	22.95
360.00	-131.40	0.00	2968.72	2968.72	23.01
361.00	-132.40	0.00	2973.33	2973.33	23.07
362.00	-133.40	0.00	2977.93	2977.93	23.13
363.00	-134.40	0.00	2982.52	2982.52	23.19
364.00	-135.40	0.00	2987.10	2987.10	23.25
365.00	-136.40	0.00	2991.67	2991.67	23.31
366.00	-137.40	0.00	2996.22	2996.22	23.37
367.00	-138.40	0.00	3000.77	3000.77	23.43
368.00	-139.40	0.00	3005.30	3005.30	23.48
369.00	-140.40	0.00	3009.83	3009.83	23.54
370.00	-141.40	0.00	3014.34	3014.34	23.60
371.00	-142.40	0.00	3018.84	3018.84	23.66
372.00	-143.40	0.00	3023.34	3023.34	23.72
373.00	-144.40	0.00	3027.82	3027.82	23.78
374.00	-145.40	0.00	3032.29	3032.29	23.84
375.00	-146.40	0.00	3036.75	3036.75	23.90
376.00	-147.40	0.00	3041.20	3041.20	23.96
377.00	-148.40	0.00	3045.64	3045.64	24.02
378.00	-149.40	0.00	3050.07	3050.07	24.08
379.00	-150.40	0.00	3054.50	3054.50	24.14
380.00	-151.40	0.00	3058.91	3058.91	24.20
381.00	-152.40	0.00	3063.31	3063.31	24.26
382.00	-153.40	0.00	3067.70	3067.70	24.32

383.00	-154.40	0.00	3072.09	3072.09	24.38
384.00	-155.40	0.00	3076.46	3076.46	24.44
385.00	-156.40	0.00	3080.83	3080.83	24.51
386.00	-157.40	0.00	3085.18	3085.18	24.57
387.00	-158.40	0.00	3089.53	3089.53	24.63
388.00	-159.40	0.00	3093.86	3093.86	24.69
389.00	-160.40	0.00	3098.19	3098.19	24.75
390.00	-161.40	0.00	3102.51	3102.51	24.81
391.00	-162.40	0.00	3106.82	3106.82	24.87
392.00	-163.40	0.00	3111.12	3111.12	24.93
393.00	-164.40	0.00	3115.42	3115.42	24.99
394.00	-165.40	0.00	3119.70	3119.70	25.06
395.00	-166.40	0.00	3123.98	3123.98	25.12
396.00	-167.40	0.00	3128.25	3128.25	25.18
397.00	-168.40	0.00	3132.50	3132.50	25.24
398.00	-169.40	0.00	3136.75	3136.75	25.30
399.00	-170.40	0.00	3141.00	3141.00	25.36
400.00	-171.40	0.00	3145.23	3145.23	25.43
401.00	-172.40	0.00	3149.46	3149.46	25.49
402.00	-173.40	0.00	3153.67	3153.67	25.55
403.00	-174.40	0.00	3157.88	3157.88	25.61
404.00	-175.40	0.00	3162.09	3162.09	25.67
405.00	-176.40	0.00	3166.28	3166.28	25.74
406.00	-177.40	0.00	3170.47	3170.47	25.80
407.00	-178.40	0.00	3174.64	3174.64	25.86
408.00	-179.40	0.00	3178.81	3178.81	25.92
409.00	-180.40	0.00	3182.98	3182.98	25.99
410.00	-181.40	0.00	3187.13	3187.13	26.05
411.00	-182.40	0.00	3191.28	3191.28	26.11
412.00	-183.40	0.00	3195.42	3195.42	26.18
413.00	-184.40	0.00	3199.55	3199.55	26.24
414.00	-185.40	0.00	3203.68	3203.68	26.30
415.00	-186.40	0.00	3207.79	3207.79	26.37
416.00	-187.40	0.00	3211.90	3211.90	26.43
417.00	-188.40	0.00	3216.01	3216.01	26.49
418.00	-189.40	0.00	3220.10	3220.10	26.56
419.00	-190.40	0.00	3224.19	3224.19	26.62
420.00	-191.40	0.00	3228.27	3228.27	26.68
421.00	-192.40	0.00	3232.35	3232.35	26.75
422.00	-193.40	0.00	3236.41	3236.41	26.81
423.00	-194.40	0.00	3240.47	3240.47	26.87
424.00	-195.40	0.00	3244.53	3244.53	26.94
425.00	-196.40	0.00	3248.57	3248.57	27.00
426.00	-197.40	0.00	3252.61	3252.61	27.07
427.00	-198.40	0.00	3256.65	3256.65	27.13
428.00	-199.40	0.00	3260.67	3260.67	27.19
429.00	-200.40	0.00	3264.69	3264.69	27.26
430.00	-201.40	0.00	3268.70	3268.70	27.32
431.00	-202.40	0.00	3272.71	3272.71	27.39
432.00	-203.40	0.00	3276.71	3276.71	27.45
433.00	-204.40	0.00	3280.70	3280.70	27.52
434.00	-205.40	0.00	3284.69	3284.69	27.58
435.00	-206.40	0.00	3288.67	3288.67	27.65

436.00	-207.40	0.00	3292.64	3292.64	27.71
437.00	-208.40	0.00	3296.61	3296.61	27.78
438.00	-209.40	0.00	3300.57	3300.57	27.84
439.00	-210.40	0.00	3304.52	3304.52	27.91
440.00	-211.40	0.00	3308.47	3308.47	27.97
441.00	-212.40	0.00	3312.41	3312.41	28.04
442.00	-213.40	0.00	3316.35	3316.35	28.10
443.00	-214.40	0.00	3320.28	3320.28	28.17
444.00	-215.40	0.00	3324.20	3324.20	28.23
445.00	-216.40	0.00	3328.12	3328.12	28.30
446.00	-217.40	0.00	3332.03	3332.03	28.36
447.00	-218.40	0.00	3335.94	3335.94	28.43
448.00	-219.40	0.00	3339.83	3339.83	28.50
449.00	-220.40	0.00	3343.73	3343.73	28.56
450.00	-221.40	0.00	3347.61	3347.61	28.63
451.00	-222.40	0.00	3351.50	3351.50	28.69
452.00	-223.40	0.00	3355.37	3355.37	28.76
453.00	-224.40	0.00	3359.24	3359.24	28.83
454.00	-225.40	0.00	3363.11	3363.11	28.89
455.00	-226.40	0.00	3366.96	3366.96	28.96
456.00	-227.40	0.00	3370.82	3370.82	29.02
457.00	-228.40	0.00	3374.66	3374.66	29.09
458.00	-229.40	0.00	3378.50	3378.50	29.16
459.00	-230.40	0.00	3382.34	3382.34	29.22
460.00	-231.40	0.00	3386.17	3386.17	29.29
461.00	-232.40	0.00	3389.99	3389.99	29.36
462.00	-233.40	0.00	3393.81	3393.81	29.42
463.00	-234.40	0.00	3397.63	3397.63	29.49
464.00	-235.40	0.00	3401.43	3401.43	29.56
465.00	-236.40	0.00	3405.24	3405.24	29.63
466.00	-237.40	0.00	3409.03	3409.03	29.69
467.00	-238.40	0.00	3412.82	3412.82	29.76
468.00	-239.40	0.00	3416.61	3416.61	29.83
469.00	-240.40	0.00	3420.39	3420.39	29.89

Initial flashing fraction = 0.165

Initial flashing mass = 0.000 kg

Release detected at 229.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 228.600 seconds

Wind speed for max CC concentration is 1.000 m/sec

Meander factor at this wind speed is 4.00

Hor. coeff. adjusted for meander = 34.972 m

Maximum CR concentration at 120.0 seconds after detection 22.37 ppm

30 Ton Sulfur Dioxide Release at CR 1/2 w/out isolation  
Output file is 30so2cr1.out

Accident scenario is tank failure

Mass of spill, kg = 27216.00

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 64.10

Latent heat of chemical, J/kg = 388461.00

Specific heat of chemical, J/kg-K = 1511.00

Liquid density of chemical, kg/m<sup>3</sup> = 1460.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed

assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Nasal detection

Detection concentration, ppm = 3.00

Ambient temperature, K = 305.60

Boiling temperature, K = 263.20

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 1.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 5700.00

Infiltration rate after isolation, cfm = 435.00

Distance from spill to CR intake, m = 228.60

Building wake factor = 3.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 55.75

Dispersion coeff for initial flashing, m = 6.06

Unadjusted horizontal dispersion coeff., m = 8.74

Unadjusted vertical dispersion coeff., m = 4.55

Horizontal dispersion coefficient, m = 10.64

Vertical dispersion coefficient, m = 7.58

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00

Time after detection for max CR conc., sec = 120.00

Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	342.64	277.09



Time history for limiting wind speed of 1.00 m/sec

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
165.00	63.60	0.00	0.00	0.00	0.00
166.00	62.60	0.00	0.00	0.00	0.00
167.00	61.60	0.00	0.00	0.00	0.00
168.00	60.60	0.01	0.00	0.01	0.00
169.00	59.60	0.01	0.00	0.01	0.00
170.00	58.60	0.02	0.00	0.02	0.00
171.00	57.60	0.04	0.00	0.04	0.00
172.00	56.60	0.06	0.00	0.06	0.00
173.00	55.60	0.10	0.00	0.10	0.00
174.00	54.60	0.17	0.00	0.17	0.00
175.00	53.60	0.27	0.00	0.27	0.00
176.00	52.60	0.43	0.00	0.43	0.00
177.00	51.60	0.68	0.00	0.68	0.00
178.00	50.60	1.06	0.00	1.06	0.00
179.00	49.60	1.66	0.00	1.66	0.00
180.00	48.60	2.56	0.00	2.56	0.00
181.00	47.60	3.91	0.00	3.91	0.00
182.00	46.60	5.93	0.00	5.93	0.00
183.00	45.60	8.90	0.00	8.90	0.01
184.00	44.60	13.26	0.00	13.26	0.01
185.00	43.60	19.58	0.00	19.58	0.02
186.00	42.60	28.65	0.00	28.65	0.02
187.00	41.60	41.55	0.00	41.55	0.03
188.00	40.60	59.74	0.00	59.74	0.05
189.00	39.60	85.13	0.00	85.13	0.07
190.00	38.60	120.24	0.00	120.24	0.10
191.00	37.60	168.35	0.00	168.35	0.15
192.00	36.60	233.62	0.00	233.62	0.21
193.00	35.60	321.36	0.00	321.36	0.29
194.00	34.60	438.16	0.00	438.16	0.40
195.00	33.60	592.16	0.00	592.16	0.56
196.00	32.60	793.24	0.00	793.24	0.76
197.00	31.60	1053.27	0.00	1053.27	1.04
198.00	30.60	1386.23	0.00	1386.23	1.40
199.00	29.60	1808.41	0.00	1808.41	1.87
200.00	28.60	2338.42	0.00	2338.42	2.48
201.00	27.60	2997.18	0.00	2997.18	3.26
202.00	26.60	3807.73	0.00	3807.73	4.25
203.00	25.60	4794.94	0.00	4794.94	5.49
204.00	24.60	5985.01	0.00	5985.01	7.05
205.00	23.60	7404.75	0.00	7404.75	8.98
206.00	22.60	9080.72	0.00	9080.72	11.34
207.00	21.60	11038.09	0.00	11038.09	14.21
208.00	20.60	13299.40	0.00	13299.40	17.67
209.00	19.60	15883.05	0.00	15883.05	21.80

210.00	18.60	18801.82	0.00	18801.82	26.68
211.00	17.60	21199.77	0.00	21199.77	32.20
212.00	16.60	21498.26	0.00	21498.26	37.78
213.00	15.60	21783.13	0.00	21783.13	43.44
214.00	14.60	22053.73	0.00	22053.73	49.17
215.00	13.60	22309.45	0.00	22309.45	54.97
216.00	12.60	22549.69	0.00	22549.69	60.82
217.00	11.60	22773.89	0.00	22773.89	66.73
218.00	10.60	22981.51	0.00	22981.51	72.70
219.00	9.60	23172.08	0.00	23172.08	78.71
220.00	8.60	23345.13	0.00	23345.13	84.77
221.00	7.60	23500.26	0.00	23500.26	90.86
222.00	6.60	23637.08	0.00	23637.08	96.99
223.00	5.60	23755.26	0.00	23755.26	103.15
224.00	4.60	23854.52	0.00	23854.52	109.33
225.00	3.60	23934.62	0.00	23934.62	115.53
226.00	2.60	23995.37	0.00	23995.37	121.75
227.00	1.60	24036.60	0.00	24036.60	127.97
228.00	0.60	24058.23	0.00	24058.23	134.20
229.00	-0.40	24060.20	402.07	24462.27	140.54
230.00	-1.40	24042.50	2330.24	26372.74	147.36
231.00	-2.40	24005.18	1764.22	25769.39	154.03
232.00	-3.40	23948.33	1458.24	25406.56	160.61
233.00	-4.40	23872.08	1275.84	25147.92	167.11
234.00	-5.40	23776.63	1151.36	24928.00	173.56
235.00	-6.40	23662.21	1059.48	24721.69	179.95
236.00	-7.40	23529.10	988.07	24517.16	186.28
237.00	-8.40	23377.61	930.50	24308.11	192.56
238.00	-9.40	23208.11	882.82	24090.93	198.78
239.00	-10.40	23021.01	842.48	23863.49	204.94
240.00	-11.40	22816.75	807.78	23624.53	211.04
241.00	-12.40	22595.83	777.51	23373.34	217.06
242.00	-13.40	22358.75	750.81	23109.56	223.02
243.00	-14.40	22106.09	727.02	22833.10	228.91
244.00	-15.40	21838.41	705.65	22544.06	234.72
245.00	-16.40	21556.34	686.31	22242.66	240.45
246.00	-17.40	21260.53	668.71	21929.24	246.09
247.00	-18.40	19426.43	652.60	20079.02	251.25
248.00	-19.40	16439.71	637.77	17077.48	255.63
249.00	-20.40	13789.84	624.07	14413.92	259.32
250.00	-21.40	11465.38	611.37	12076.75	262.40
251.00	-22.40	9448.91	599.54	10048.45	264.94
252.00	-23.40	7718.61	588.49	8307.10	267.04
253.00	-24.40	6249.72	578.13	6827.86	268.74
254.00	-25.40	5015.87	568.41	5584.28	270.13
255.00	-26.40	3990.21	559.25	4549.46	271.24
256.00	-27.40	3146.37	550.60	3696.98	272.13
257.00	-28.40	2459.17	542.43	3001.59	272.84
258.00	-29.40	1905.15	534.68	2439.83	273.41
259.00	-30.40	1462.97	527.32	1990.29	273.85
260.00	-31.40	1113.54	520.32	1633.86	274.21
261.00	-32.40	840.12	513.64	1353.76	274.49
262.00	-33.40	628.26	507.28	1135.54	274.71

263.00	-34.40	465.69	501.20	966.89	274.89
264.00	-35.40	342.16	495.38	837.54	275.04
265.00	-36.40	249.18	489.80	738.99	275.16
266.00	-37.40	179.88	484.46	664.33	275.26
267.00	-38.40	128.70	479.32	608.03	275.35
268.00	-39.40	91.28	474.39	565.67	275.42
269.00	-40.40	64.17	469.64	533.80	275.49
270.00	-41.40	44.71	465.06	509.77	275.55
271.00	-42.40	30.88	460.65	491.53	275.61
272.00	-43.40	21.14	456.39	477.54	275.66
273.00	-44.40	14.35	452.28	466.63	275.71
274.00	-45.40	9.65	448.31	457.96	275.76
275.00	-46.40	6.43	444.47	450.90	275.80
276.00	-47.40	4.25	440.75	445.00	275.85
277.00	-48.40	2.78	437.15	439.94	275.89
278.00	-49.40	1.81	433.66	435.47	275.93
279.00	-50.40	1.16	430.27	431.44	275.97
280.00	-51.40	0.74	426.99	427.73	276.01
281.00	-52.40	0.47	423.80	424.27	276.05
282.00	-53.40	0.29	420.70	420.99	276.09
283.00	-54.40	0.18	417.68	417.87	276.13
284.00	-55.40	0.11	414.75	414.87	276.16
285.00	-56.40	0.07	411.90	411.97	276.20
286.00	-57.40	0.04	409.13	409.17	276.23
287.00	-58.40	0.02	406.42	406.45	276.27
288.00	-59.40	0.01	403.79	403.80	276.30
289.00	-60.40	0.01	401.22	401.23	276.33
290.00	-61.40	0.01	398.71	398.72	276.36
291.00	-62.40	0.00	396.27	396.27	276.39
292.00	-63.40	0.00	393.88	393.88	276.42
293.00	-64.40	0.00	391.55	391.55	276.45
294.00	-65.40	0.00	389.27	389.27	276.48
295.00	-66.40	0.00	387.05	387.05	276.51
296.00	-67.40	0.00	384.88	384.88	276.54
297.00	-68.40	0.00	382.75	382.75	276.57
298.00	-69.40	0.00	380.67	380.67	276.60
299.00	-70.40	0.00	378.63	378.63	276.62
300.00	-71.40	0.00	376.64	376.64	276.65
301.00	-72.40	0.00	374.69	374.69	276.67
302.00	-73.40	0.00	372.78	372.78	276.70
303.00	-74.40	0.00	370.91	370.91	276.72
304.00	-75.40	0.00	369.08	369.08	276.75
305.00	-76.40	0.00	367.28	367.28	276.77
306.00	-77.40	0.00	365.52	365.52	276.79
307.00	-78.40	0.00	363.79	363.79	276.82
308.00	-79.40	0.00	362.09	362.09	276.84
309.00	-80.40	0.00	360.43	360.43	276.86
310.00	-81.40	0.00	358.80	358.80	276.88
311.00	-82.40	0.00	357.20	357.20	276.90
312.00	-83.40	0.00	355.62	355.62	276.92
313.00	-84.40	0.00	354.08	354.08	276.94
314.00	-85.40	0.00	352.56	352.56	276.96
315.00	-86.40	0.00	351.07	351.07	276.98

316.00	-87.40	0.00	349.60	349.60	277.00
317.00	-88.40	0.00	348.16	348.16	277.02
318.00	-89.40	0.00	346.75	346.75	277.04
319.00	-90.40	0.00	345.35	345.35	277.06
320.00	-91.40	0.00	343.98	343.98	277.07
321.00	-92.40	0.00	342.64	342.64	277.09
322.00	-93.40	0.00	341.31	341.31	277.11
323.00	-94.40	0.00	340.01	340.01	277.12
324.00	-95.40	0.00	338.72	338.72	277.14
325.00	-96.40	0.00	337.46	337.46	277.16
326.00	-97.40	0.00	336.22	336.22	277.17
327.00	-98.40	0.00	334.99	334.99	277.19
328.00	-99.40	0.00	333.79	333.79	277.20
329.00	-100.40	0.00	332.60	332.60	277.21
330.00	-101.40	0.00	331.43	331.43	277.23
331.00	-102.40	0.00	330.27	330.27	277.24
332.00	-103.40	0.00	329.14	329.14	277.26
333.00	-104.40	0.00	328.02	328.02	277.27
334.00	-105.40	0.00	326.91	326.91	277.28
335.00	-106.40	0.00	325.83	325.83	277.30
336.00	-107.40	0.00	324.75	324.75	277.31
337.00	-108.40	0.00	323.70	323.70	277.32
338.00	-109.40	0.00	322.65	322.65	277.33
339.00	-110.40	0.00	321.62	321.62	277.34
340.00	-111.40	0.00	320.61	320.61	277.35
341.00	-112.40	0.00	319.61	319.61	277.37
342.00	-113.40	0.00	318.62	318.62	277.38
343.00	-114.40	0.00	317.64	317.64	277.39
344.00	-115.40	0.00	316.68	316.68	277.40
345.00	-116.40	0.00	315.73	315.73	277.41
346.00	-117.40	0.00	314.79	314.79	277.42
347.00	-118.40	0.00	313.87	313.87	277.43
348.00	-119.40	0.00	312.95	312.95	277.43
349.00	-120.40	0.00	312.05	312.05	277.44
350.00	-121.40	0.00	311.16	311.16	277.45
351.00	-122.40	0.00	310.28	310.28	277.46
352.00	-123.40	0.00	309.41	309.41	277.47
353.00	-124.40	0.00	308.55	308.55	277.48
354.00	-125.40	0.00	307.70	307.70	277.49
355.00	-126.40	0.00	306.86	306.86	277.49
356.00	-127.40	0.00	306.04	306.04	277.50
357.00	-128.40	0.00	305.22	305.22	277.51
358.00	-129.40	0.00	304.41	304.41	277.51
359.00	-130.40	0.00	303.61	303.61	277.52
360.00	-131.40	0.00	302.82	302.82	277.53
361.00	-132.40	0.00	302.03	302.03	277.53
362.00	-133.40	0.00	301.26	301.26	277.54
363.00	-134.40	0.00	300.50	300.50	277.55
364.00	-135.40	0.00	299.74	299.74	277.55
365.00	-136.40	0.00	298.99	298.99	277.56
366.00	-137.40	0.00	298.25	298.25	277.56
367.00	-138.40	0.00	297.52	297.52	277.57
368.00	-139.40	0.00	296.80	296.80	277.57

369.00	-140.40	0.00	296.08	296.08	277.58
370.00	-141.40	0.00	295.38	295.38	277.58
371.00	-142.40	0.00	294.68	294.68	277.59
372.00	-143.40	0.00	293.98	293.98	277.59
373.00	-144.40	0.00	293.30	293.30	277.60
374.00	-145.40	0.00	292.62	292.62	277.60
375.00	-146.40	0.00	291.95	291.95	277.60
376.00	-147.40	0.00	291.28	291.28	277.61
377.00	-148.40	0.00	290.62	290.62	277.61
378.00	-149.40	0.00	289.97	289.97	277.61
379.00	-150.40	0.00	289.33	289.33	277.62
380.00	-151.40	0.00	288.69	288.69	277.62
381.00	-152.40	0.00	288.06	288.06	277.62
382.00	-153.40	0.00	287.43	287.43	277.62
383.00	-154.40	0.00	286.81	286.81	277.63
384.00	-155.40	0.00	286.20	286.20	277.63
385.00	-156.40	0.00	285.59	285.59	277.63
386.00	-157.40	0.00	284.98	284.98	277.63
387.00	-158.40	0.00	284.39	284.39	277.64
388.00	-159.40	0.00	283.80	283.80	277.64
389.00	-160.40	0.00	283.21	283.21	277.64
390.00	-161.40	0.00	282.63	282.63	277.64
391.00	-162.40	0.00	282.06	282.06	277.64
392.00	-163.40	0.00	281.49	281.49	277.64
393.00	-164.40	0.00	280.92	280.92	277.64
394.00	-165.40	0.00	280.37	280.37	277.64
395.00	-166.40	0.00	279.81	279.81	277.64
396.00	-167.40	0.00	279.26	279.26	277.64
397.00	-168.40	0.00	278.72	278.72	277.64
398.00	-169.40	0.00	278.18	278.18	277.64
399.00	-170.40	0.00	277.65	277.65	277.64
400.00	-171.40	0.00	277.12	277.12	277.64
401.00	-172.40	0.00	276.59	276.59	277.64
402.00	-173.40	0.00	276.07	276.07	277.64
403.00	-174.40	0.00	275.55	275.55	277.64
404.00	-175.40	0.00	275.04	275.04	277.64
405.00	-176.40	0.00	274.54	274.54	277.64
406.00	-177.40	0.00	274.03	274.03	277.64
407.00	-178.40	0.00	273.53	273.53	277.64
408.00	-179.40	0.00	273.04	273.04	277.64
409.00	-180.40	0.00	272.55	272.55	277.64
410.00	-181.40	0.00	272.06	272.06	277.64
411.00	-182.40	0.00	271.58	271.58	277.63
412.00	-183.40	0.00	271.10	271.10	277.63
413.00	-184.40	0.00	270.63	270.63	277.63
414.00	-185.40	0.00	270.16	270.16	277.63
415.00	-186.40	0.00	269.69	269.69	277.63
416.00	-187.40	0.00	269.23	269.23	277.62
417.00	-188.40	0.00	268.77	268.77	277.62
418.00	-189.40	0.00	268.31	268.31	277.62
419.00	-190.40	0.00	267.86	267.86	277.62
420.00	-191.40	0.00	267.41	267.41	277.61
421.00	-192.40	0.00	266.97	266.97	277.61

422.00	-193.40	0.00	266.53	266.53	277.61
423.00	-194.40	0.00	266.09	266.09	277.61
424.00	-195.40	0.00	265.65	265.65	277.60
425.00	-196.40	0.00	265.22	265.22	277.60
426.00	-197.40	0.00	264.80	264.80	277.60
427.00	-198.40	0.00	264.37	264.37	277.59
428.00	-199.40	0.00	263.95	263.95	277.59
429.00	-200.40	0.00	263.53	263.53	277.59
430.00	-201.40	0.00	263.12	263.12	277.58
431.00	-202.40	0.00	262.70	262.70	277.58
432.00	-203.40	0.00	262.29	262.29	277.57
433.00	-204.40	0.00	261.89	261.89	277.57
434.00	-205.40	0.00	261.48	261.48	277.57
435.00	-206.40	0.00	261.08	261.08	277.56
436.00	-207.40	0.00	260.69	260.69	277.56
437.00	-208.40	0.00	260.29	260.29	277.55
438.00	-209.40	0.00	259.90	259.90	277.55
439.00	-210.40	0.00	259.51	259.51	277.54
440.00	-211.40	0.00	259.13	259.13	277.54
441.00	-212.40	0.00	258.74	258.74	277.53

Initial flashing fraction = 0.165

Initial flashing mass = 4488.562 kg

Release detected at 201.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 26.46

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 228.600 seconds

Wind speed for max CC concentration is 1.000 m/sec

Meander factor at this wind speed is 4.00

Hor. coeff. adjusted for meander = 34.972 m

Maximum CR concentration at 120.0 seconds after detection 277.09 ppm

c This FORTRAN code will calculate the control room concentration of a  
c particular toxic gas following a postulated failure of a chemical container.  
c The methodology used in this code follows the guidance provided in NUREG  
c 0570 and NUREG/CR-3786, as well as Regulatory Guides 1.78 and 1.145. The code  
c prompts the user to specify an input file name of eight characters,  
c with no extension, 'filename'. Data is written to the output file called  
c 'filename.out'. This output file contains an echo of the input data as well as  
c the calculated control complex concentration as a function of time. A range of  
c wind speeds are examined to determine the limiting wind speed in terms of  
c control complex concentration.  
c  
c The input file requires the following information:  
c Line 1; Title or description of scenario being modeled  
c Line 2; M: Mass [kg] of chemical release  
c MW: Molecular weight of chemical  
c cp: Specific heat of chemical [J/kg-K]  
c hfg: Latent heat of vaporization of chemical [J/kg]  
c rholiq: Density of saturated liquid of chemical [kg/m<sup>3</sup>]  
c Tb: Boiling temperature of chemical [K]  
c Ta: Ambient temperature [K]  
c Line 3; Umin: Minimum wind speed for analysis [m/s]  
c Umax: Maximum wind speed for analysis [m/s]  
c dU: Wind speed increment [m/s]  
c Line 4; V: Volume of control complex [m<sup>3</sup>]  
c Wo: Ventilation rate before isolation [cfm]  
c Wiso: Infiltration rate after isolation [cfm]  
c PPMd: Detectable concentration [ppm]  
c tdelay: Delay time from detection to isolation [s]  
c Line 5; L: Distance from source to control room intake [m]  
c h: Above-ground elevation of source [m]  
c z: Above-ground elevation of intake [m]  
c SC: Pasquill atmospheric stability class where  
c 1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G  
c Amax: Max surface area of spill if limited by a berm [m<sup>2</sup>]  
c If no berm, input Amax = 0.0  
c WF: Wake factor for building for wake effects  
c Line 6; imode: Control flag for accident scenario  
c imode = 1; failure of single container  
c imode = 2; slow leak due to valve leakage  
c Ma: Total mass available for leakage [kg]  
c Qdot1: Constant vapor release rate for valve leakage [kg/s]  
c Qdot2: Constant liquid release rate for valve leakage [kg/s]  
c Line 7; dt: Time step for analysis [s]  
c tmax: Maximum time for analysis [s]  
c tad: Time after detection for determining maximum control  
c room concentration, usually two minutes [s]  
c tstop: Program stops 'tstop' seconds after maximum control  
c room concentration is determined  
c ifdetect: Control flag for chemical detection logic,  
c ifdetect = 1; nasal detection in control complex  
c ifdetect = 2; detection at intake by sensor

```

c      ifgas: Control flag for calculating chemical concentrations
c      ifgas=0 for no adjustments made to source/intake elevations
c      ifgas=1 for lighter than air option for Gaussian model, h=z
c      ifgas=2 for heavier than air option for Gaussian model, h=z=0
c      ifgas=3 for heavier than air option for Gaussian model, h=z=0;
c      also employs NUREG/CR-3786 method and selects minimum
c      concentration at intake

```

program toxic

implicit double precision (A-H,O-Z)

double precision L,Lkm,MWa,MW,M,Mi,Me,Mf,Ma,mdot,Mleak,Me2

character input\*8, file1\*12, file2\*12, file3\*12

character title\*60

dimension data(100000,3), mdot(200000)

write(\*,\*)'Enter name of input file'

read(\*,100)input

file1=input/'".out"

file2=input/'".sar"

file3=input/'".evp"

open(unit=9,file=input,status='unknown')

open(unit=10,file=file1,status='unknown')

open(unit=11,file=file2,status='unknown')

open(unit=12,file=file3,status='unknown')

read(9,100)title

read(9,\*)M,MW,cp,hfg,rholiq,Tb,Ta

read(9,\*)Umin,Umax,dU

read(9,\*)V,Wo,Wiso,PPMd,tdelay

read(9,\*)L,h,z,SC,Amax,WF

read(9,\*)imode,Ma,Qdot1,Qdot2

read(9,\*)dt,tmax,tad,tstop,ifdect,ifgas

```

write(11,115)'time','Mass','Volume','dMdt','Area',
&      '(sec)','(kg)','(m^3)','(kg/s)','(m^2)'
write(11,*)

```

c constants

pi=4.0\*atan(1.0)

g=9.81

Rg=8314

MWa=28.97

c density of air and chemical vapor in [kg/m^3]

RHOa=(1.013\*10\*\*5\*MWA)/(Rg\*Ta)

RHOv=(1.013\*10\*\*5\*MW)/(Rg\*Ta)



c initial flashing fraction, xi, and flashing mass, Mi[kg]  
 $xi = cp \cdot (Ta - Tb) / hfg$   
 $Mi = xi \cdot M$

c dispersion coefficients, [m]  
 $SIGi = (Mi / (\sqrt{2 \cdot \pi \cdot 3} \cdot RHOv))^{**}(1/3.)$   
 $Lkm = L / 1000.0$

c Pasquill stability class A

If(SC .eq. 1) then

c=24.167

d=2.5334

th=0.017453293\*(c-d\*LOG(Lkm))

SIGHi=465.11628\*Lkm\*TAN(th)

SIG800=171.398

If(Lkm .lt. 0.1) then

a=122.8

b=0.9447

Else If(Lkm .ge. 0.1 .and. Lkm .lt. 0.15) then

a=158.08

b=1.0542

Else If(Lkm .ge. 0.15 .and. Lkm .lt. 0.2) then

a=170.22

b=1.0932

Else If(Lkm .ge. 0.2 .and. Lkm .lt. 0.25) then

a=179.52

b=1.1262

Else If(Lkm .ge. 0.25 .and. Lkm .lt. 0.3) then

a=217.41

b=1.2644

Else If(Lkm .ge. 0.3 .and. Lkm .lt. 0.4) then

a=258.89

b=1.4094

Else If(Lkm .ge. 0.4 .and. Lkm .lt. 0.5) then

a=346.75

b=1.7283

Else If(Lkm .ge. 0.5 .and. Lkm .lt. 3.11) then

a=453.85

b=2.1166

EndIf

$SIGVi = a \cdot Lkm^{**}b$

If(Lkm .ge. 3.11) SIGVi=5000.0

If(SIGVi .gt. 5000.0) SIGVi=5000.0

EndIf

c Pasquill stability class B

If(SC .eq. 2) then

c=18.333

d=1.8096

th=0.017453293\*(c-d\*LOG(Lkm))

$SIGH_i = 465.11628 * Lkm * TAN(th)$   
 $SIG800 = 126.2130$

If(Lkm .lt. 0.2) then  
a=90.673  
b=0.93198  
Else If(Lkm .ge. 0.2 .and. Lkm .lt. 0.4) then  
a=98.483  
b=0.98332  
Else If(Lkm .ge. 0.4) then  
a=109.3  
b=1.0971  
EndIf

$SIGVi = a * Lkm ** b$   
If(SIGVi .gt. 5000.0) SIGVi=5000.0  
EndIf

c Pasquill stability class C

If(SC .eq. 3) then  
c=12.5  
d=1.0857  
th=0.017453293\*(c-d\*LOG(Lkm))  
 $SIGH_i = 465.11628 * Lkm * TAN(th)$   
 $SIG800 = 84.1433$

a=61.141  
b=0.91465  
 $SIGVi = a * Lkm ** b$   
If(SIGVi .gt. 5000.0) SIGVi=5000.0  
EndIf

c Pasquill stability class D

If(SC .eq. 4) then  
c=8.333  
d=0.72382  
th=0.017453293\*(c-d\*LOG(Lkm))  
 $SIGH_i = 465.11628 * Lkm * TAN(th)$   
 $SIG800 = 55.5733$

If(Lkm .lt. 0.3) then  
a=34.459  
b=0.86974  
Else If(Lkm .ge. 0.3 .and. Lkm .lt. 1.0) then  
a=32.093  
b=0.81066  
Else If(Lkm .ge. 1.0 .and. Lkm .lt. 3.0) then  
a=32.093  
b=0.64403  
Else If(Lkm .ge. 3.0 .and. Lkm .lt. 10.0) then  
a=33.504  
b=0.60486  
Else If(Lkm .ge. 10.0 .and. Lkm .lt. 30.0) then

```
a=36.65
b=0.56589
Else If(Lkm .ge. 30.0) then
a=44.053
b=0.51179
EndIf
```

```
SIGVi=a*Lkm**b
EndIf
```

c Pasquill stability class E

```
If(SC .eq. 5) then
c=6.25
d=0.54287
th=0.017453293*(c-d*LOG(Lkm))
SIGHi=465.11628*Lkm*TAN(th)
SIG800=41.5471
```

```
If(Lkm .lt. 0.1) then
a=24.26
b=0.8366
Else If(Lkm .ge. 0.1 .and. Lkm .lt. 0.3) then
a=23.331
b=0.81956
Else If(Lkm .ge. 0.3 .and. Lkm .lt. 1.0) then
a=21.628
b=0.7566
Else If(Lkm .ge. 1.0 .and. Lkm .lt. 2.0) then
a=21.628
b=0.63077
Else If(Lkm .ge. 2.0 .and. Lkm .lt. 4.0) then
a=22.534
b=0.57154
Else If(Lkm .ge. 4.0 .and. Lkm .lt. 10.0) then
a=24.703
b=0.50527
Else If(Lkm .ge. 10.0 .and. Lkm .lt. 20.0) then
a=26.97
b=0.46713
Else If(Lkm .ge. 20.0 .and. Lkm .lt. 40.0) then
a=35.42
b=0.37615
Else If(Lkm .ge. 40.0) then
a=47.618
b=0.29592
EndIf
```

```
SIGVi=a*Lkm**b
EndIf
```

c Pasquill stability class F and G

If(SC .eq. 6 .or. SC .eq. 7) then

c=4.1667

d=0.36191

th=0.017453293\*(c-d\*LOG(Lkm))

SIGHi=465.11628\*Lkm\*TAN(th)

SIG800=27.6347

If(Lkm .lt. 0.2) then

a=15.209

b=0.81558

Else If(Lkm .ge. 0.2 .and. Lkm .lt. 0.7) then

a=14.457

b=0.78407

Else If(Lkm .ge. 0.7 .and. Lkm .lt. 1.0) then

a=13.953

b=0.68465

Else If(Lkm .ge. 1.0 .and. Lkm .lt. 2.0) then

a=13.953

b=0.63227

Else If(Lkm .ge. 2.0 .and. Lkm .lt. 3.0) then

a=14.823

b=0.54503

Else If(Lkm .ge. 3.0 .and. Lkm .lt. 7.0) then

a=16.187

b=0.4649

Else If(Lkm .ge. 7.0 .and. Lkm .lt. 15.0) then

a=17.836

b=0.41507

Else If(Lkm .ge. 15.0 .and. Lkm .lt. 30.0) then

a=22.651

b=0.32681

Else If(Lkm .ge. 30.0 .and. Lkm .lt. 60.0) then

a=27.074

b=0.27436

Else If(Lkm .ge. 60.0) then

a=34.219

b=0.21716

EndIf

SIGVi=a\*Lkm\*\*b

If(SC .eq. 7) then

SIGHi=2/3.\*SIGHi

SIGVi=3/5.\*SIGVi

SIG800=2/3.\*27.6347

EndIf

EndIf

SIGx=SQRT(SIGHi\*\*2+SIGi\*\*2)

SIGy=SIGx

SIGz=SQRT(SIGVi\*\*2+SIGi\*\*2)

```
c  select option for puff concentration calculation,
    If(ifgas.eq.1) h=z
    If(ifgas.eq.2 .or. ifgas.eq.3) then
        z2=z
        h=0.0
        z=0.0
    Endif

write(10,*)title
write(10,*)'Output file is ',file1
write(10,107)
If(imode.eq.1)write(10,110)'Accident scenario is tank failure'
If(imode.eq.2)write(10,110)'Accident scenario is valve failure'
write(10,103)'Mass of spill, kg =' ,M
write(10,103)'Mass available for leakage, kg =' ,Ma
write(10,103)'Valve vapor leakage rate, kg/s =' ,Qdot1
write(10,103)'Valve liquid leakage rate, kg/s =' ,Qdot2
write(10,103)'Molecular weight of chemical =' ,MW
write(10,103)'Latent heat of chemical, J/kg =' ,hfg
write(10,103)'Specific heat of chemical, J/kg-K =' ,cp
write(10,103)'Liquid density of chemical, kg/m^3 =' ,rho_liq
If(ifgas.eq.0)write(10,110)'No adjustment made to elevations'
If(ifgas.eq.1)write(10,110)'Lighter than air model; h = z'
If(ifgas.eq.2)then
    write(10,110),
    & 'Heavier than air model for Gaussian distribution; h = z = 0'
Endif
If(ifgas.eq.3)then
    write(10,110),
    & 'Heavier than air model for Gaussian distribution; h = z = 0'
    write(10,110)'NUREG/CR-3786 concentration calculation performed'
    write(10,110)'assuming uniform vertical distribution at intake;'
    write(10,110)
    & 'Minimum intake concentration between two models is used'
Endif
If(ifdect.eq.1)write(10,110)'Nasal detection'
If(ifdect.eq.2)write(10,110)'Detection at intake'
write(10,103)'Detection concentration, ppm =' ,PPMd
write(10,103)'Ambient temperature, K =' ,Ta
write(10,103)'Boiling temperature, K =' ,Tb
write(10,103)'Minimum wind speed, m/sec =' ,Umin
write(10,103)'Maximum wind speed, m/sec =' ,Umax
write(10,103)'Wind speed increment, m/sec =' ,dU
write(10,103)'Atmospheric stability class is type ',SC
write(10,100)'1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G'
write(10,103)'Ventilation rate before isolation, cfm =' ,Wo
write(10,103)'Infiltration rate after isolation, cfm =' ,Wiso
write(10,103)'Distance from spill to CR intake, m =' ,L
write(10,103)'Building wake factor =' ,WF
write(10,103)'Maximum area of spill; 0 if no berm, ft^2 =' ,Amax
```

```

write(10,103)'Dispersion coeff for initial flashing, m =',SIGi
write(10,103)'Unadjusted horizontal dispersion coef., m =',SIGHi
write(10,103)'Unadjusted vertical dispersion coef., m =',SIGVi
write(10,103)'Horizontal dispersion coefficient, m =', SIGx
write(10,103)'Vertical dispersion coefficient, m =', SIGz
write(10,103)'Above ground elevation of CR intake, m =',z
write(10,103)'Above ground elevation of spill, m =',h
write(10,103)'Maximum time, sec =',tmax
write(10,103)'Time increment, sec =',dt
write(10,103)'Time after detection for max CR conc., sec =',tad
write(10,108)'Problem stopped at',tstop,'seconds after max Cr'
write(10,*)
write(10,107)
write(10,113)'Maximum CR concentration at',tad,
& 'seconds after detection versus wind speed'
write(10,111)'Wind speed, U','Intake Concentration, Co',
& 'Control Room Concentration, Cr','(m/sec)','(ppm)','(ppm)'

```

```

ifulim=0
Qdot1o=Qdot1
Qdot2o=Qdot2

```

- c start outer loop, spanning the range of wind speeds  
imax=INT((Umax-Umin)/dU)+1

```
do 30 i=1,imax
```

- c set wind speed and ventilation rate  
U=Umin+(i-1)\*dU

```

15 W=Wo
Qdot1=Qdot1o
Qdot2=Qdot2o

```

- c meander factor as a function of stability class and wind speed  
Mf=1.0

```

If(SC .eq. 4) then
  If(U .le. 2.0) then
    Mf=2.0
  Else If(U .gt. 2.0 .and. U .le. 6.0) then
    Mf=3.097*U**-0.631
  Else If (U .gt. 6.0) then
    Mf=1.0
  Endif
Endif

```

```

If(SC .eq. 5) then
  If(U .le. 2.0) then
    Mf=3.0
  Else If(U .gt. 2.0 .and. U .le. 6.0) then
    Mf=6.0*U**-1.0
  Else If (U .gt. 6.0) then
    Mf=1.0

```

Endif  
Endif

If(SC .eq. 6) then  
  If(U .le. 2.0) then  
    Mf=4.0  
  Else If(U .gt. 2.0 .and. U .le. 6.0) then  
    Mf=9.592\*U\*\*-1.262  
  Else If (U .gt. 6.0) then  
    Mf=1.0  
  Endif  
Endif

If(SC .eq. 7) then  
  If(U .le. 2.0) then  
    Mf=6.0  
  Else If(U .gt. 2.0 .and. U .le. 6.0) then  
    Mf=18.583\*U\*\*-1.631  
  Else If (U .gt. 6.0) then  
    Mf=1.0  
  Endif  
Endif

- c compute horizontal dispersion coeff. including meander  
  If(L.le.800.0) then  
    SIGMAy=Mf\*SIGHi  
  Else  
    SIGMAy=(Mf-1)\*SIG800+SIGHi  
  Endif
- c mass/volume available for evaporation, Me [kg], Ve [m^3]  
  Me=(1-xi)\*M  
  Ve=Me/RHoliq  
  ro=(Ve/pi)\*\*(1/3.)
- c time when center of puff and plume reach intake  
  tL=L/U
- c set flag to control when max control complex concentration is  
  written to data array  
  ifiso1=0  
  ifiso2=0
- c start time loop for a specific wind speed  
  jmax=INT(tmax/dt)+1  
  jdelta=INT(tL/dt)+1
- c initialize time and other variables  
  t=0.0  
  tiso=1.0e6

```

tCR=1.0e6
Co=0.0
Cr=0.0
Crold=0.0
do 10 n=1,200000
  mdot(n)=0.0
10  continue

do 20 j=1,jmax
  told=t

c  check time, isolate CR if appropriate
  If(t.ge.tiso .and. ifdect .eq. 2) W=Wiso
c  infiltration rate R [sec^-1]
  R=W/(60.0*V)

c  puff concentration, Xpuff [kg/m^3]
  x=L-U*t
  y=0.0
  Xpuff1=Mi/((2*pi)**1.5*SIGx*SIGy*SIGz*WF)
  Xpuff3=Mi/((2*pi)**1.5*SIGMAy**2*SIGz)

  pufex1=EXP(-0.5*(x**2/SIGx**2+y**2/SIGy**2))*
&  (EXP(-0.5*(z-h)**2/SIGz**2)+
&  EXP(-0.5*(z+h)**2/SIGz**2))
  pufex3=EXP(-0.5*(x**2/SIGMAy**2+y**2/SIGMAy**2))*
&  (EXP(-0.5*(z-h)**2/SIGz**2)+
&  EXP(-0.5*(z+h)**2/SIGz**2))

  Xpuff1=Xpuff1*pufex1
  Xpuff3=Xpuff3*pufex3
  Xpuff=MIN(Xpuff1,Xpuff3)

c  use alternate methodology of NUREG/CR-3786 if appropriate
  If(ifgas.eq.3) then
    altpuf=Mi/(2*pi*SIGx**2*z2)*EXP(-0.5*(x**2/SIGx**2))
    If(altpuf.lt.Xpuff) Xpuff=altpuf
  Endif

c  puff concentration, [ppm]
  PPMpuf=Xpuff*1.0E6/RHOv

c  plume concentration
c  compute maximum spill area A [m^2] based on 1 cm depth
  If(imode .eq. 1) then
    A1=(M-Mi)/RHOLIq/(0.01)
c  compute spill area per NUREG 0570, and compare to Amax and A1
    Area=pi*(ro**2+2*t*SQRT(g*Ve/pi*(RHOLIq-RHOa)/RHOLIq))
    If(Area.gt.Amax.and.Amax.ne.0.0)Area=Amax
    If(Area.gt.A1)Area=A1
    If(Ve.eq.0.0)Area=0.0

```



- c For continuous leakage scenario  
 Else If(imode .eq. 2) then  
 $M_{leak} = (Q_{dot1} + Q_{dot2}) * t$   
 If( $M_{leak}$  .ge.  $M_a$ ) then  
 $Q_{dot1} = 0.0$   
 $Q_{dot2} = 0.0$   
 Endif
- If( $t$  .eq. 0.0) then  
 $Me2 = Q_{dot2} * dt$   
 $Area = Me2 / (RH_{liq} * (0.01))$   
 Else  
 $Me2 = Me2 + (Q_{dot2} - m_{dot}(j-1)) * dt$   
 $Area = Me2 / (RH_{liq} * (0.01))$   
 Endif  
 Endif
- c calculate continous source strength due to evaporation [kg/sec]  
 If( $t$  .eq. 0.0) then  
 $t = dt$   
 $m_{dot}(j) = Area * 4.186 * (275 + (1.6 * (U/1.0) ** 0.6 + 197/t ** 0.5) * (T_a - T_b)) / h_{fg}$   
 $t = 0.0$   
 Else  
 $m_{dot}(j) = Area * 4.186 * (275 + (1.6 * (U/1.0) ** 0.6 + 197/t ** 0.5) * (T_a - T_b)) / h_{fg}$   
 Endif
- c compute spill mass/volume remaining after evaporation,  
 $Me = Me - m_{dot}(j) * dt$   
 If( $Me$  .le. 0.0)  $Me = 0.0$   
 $Ve = Me / RH_{liq}$
- c plume concentration,  $X_{plume}$  [kg/m<sup>3</sup>]  
 c add continuous release due to other sources, i.e. valve leak  
 c allow for plume travel time to intake  
 If( $t$  .lt.  $t_L$ ) then  
 $dM_{dt} = 0.0$   
 Else  
 $dM_{dt} = m_{dot}(j - j_{delta}) + Q_{dot1}$   
 Endif
- $X_{plum1} = dM_{dt} / (U * \pi * WF * SIG_y * SIG_z)$   
 $X_{plum3} = dM_{dt} / (U * \pi * SIG_{MAy} * SIG_z)$   
 $X_{plume} = MIN(X_{plum1}, X_{plum3})$   
 $pluexp = 0.5 * EXP(-0.5 * y ** 2 / SIG_y ** 2) * (EXP(-0.5 * (z-h) ** 2 / SIG_z ** 2) + EXP(-0.5 * (z+h) ** 2 / SIG_z ** 2))$   
 $X_{plume} = X_{plume} * pluexp$
- c plume concentration [ppm]

$$\text{PPMplu} = \text{Xplume} * 1.0\text{E}6 / \text{RHOv}$$

- c concentration at intake, Co [ppm], sum of puff and plume  
 $\text{Co} = (\text{PPMpuf} + \text{PPMplu})$
- c concentration in control complex, Cr [ppm]  
 $\text{Croid} = \text{Cr}$   
 $\text{Cr} = \text{Croid} + (\text{Co} - \text{Croid}) * (1 - \text{EXP}(-\text{R} * \text{dt}))$
- c continue checking concentration until detected, then set flag to 1  
 If(ifiso1.eq.0) then  
   If(ifdetect.eq.1) then  
   If(Cr.ge.PPMd) then  
   tdect=t  
   tCR=tdect+tad  
   tiso=tdect+tdelay  
   ifiso1=1  
   Endif  
 ElseIf(ifdetect.eq.2) then  
   If(Co.ge.PPMd) then  
   tdect=t  
   tCR=tdect+tad  
   tiso=tdect+tdelay  
   ifiso1=1  
   Endif  
 Endif  
 Endif  
 Endif
- c write concentrations at specified time after detection to data array  
 If(ifiso2.eq.0.and.ifiso1.eq.1.and.t.ge.tCR) then  
   data(i,1)=U  
   data(i,2)=Co  
   data(i,3)=Cr  
   ifiso2=1  
 Else If(ifiso2.eq.0.and.ifiso1.eq.0.and.j.eq.jmax) then  
   data(i,1)=U  
   data(i,2)=0.0  
   data(i,3)=0.0  
   ifiso2=1  
 Endif  
 If(ifulim.eq.1 .and. Co .ge. 0.001) then  
   write(10,101)t,x,PPMpuf,PPMplu,Co,Cr  
   write(11,116)t,Me,Ve,mdot(j),Area  
 Endif  
 If(ifulim.eq.1) write(12,117)t,mdot(j)
- t=t+dt  
 If(ifiso1.eq.1.and.t.gt.(tCR+tstop)) go to 25
- c end of time [t] loop  
 20 continue

```
c  end of wind speed [U] loop'
25  if(ifulim.eq.1) go to 50

30  continue

c  check data array to find wind speed which results in the maximum
c  control complex concentration at 'tad' seconds after detection

      Crmax=0.0
      do 40 k=1,imax
        Utemp=data(k,1)
        Crtemp=data(k,3)
        If(Crtemp.ge.Crmax) then
          Crmax=Crtemp
          kmax=k
        Endif
        write(10,112)data(k,1),data(k,2),data(k,3)
40  continue

      U=data(kmax,1)
      ifulim=1

      write(10,107)'Time history for limiting wind speed of,U,'m/sec'
      write(10,104)'time','x','Chi(puff)','Chi(plume)','Co','Cr',
&      '(sec)','(meters)','(ppm)','(ppm)','(ppm)','(ppm)'
      go to 15

50  write(10,*)' '
      write(10,106)'Initial flashing fraction = ', xi, ' '
      write(10,106)'Initial flashing mass = ', Mi, ' kg'
      write(10,106)'Release detected at ', tdect, ' seconds'
      If(ifgas.eq.1 .or. ifgas.eq.2 .or. ifgas.eq.3) then
        write(10,103)
&      'Adjusted elevation of CR intake for Gaussian model, m =',z
        If(ifgas.eq.3) write(10,103)
&      'Adjusted elev. of CR intake for NUREG/CR-3786 model, m =',z2
        write(10,103)
&      'Adjusted elevation of spill for Gaussian model, m =',h
      Endif
      write(10,106)'Arrival time of plume at intake', tL, ' seconds'
      write(10,106)'Wind speed for max CC concentration is',
&      data(kmax,1), 'm/sec'
      write(10,103)'Meander factor at this wind speed is ',Mf
      write(10,106)'Hor. coeff. adjusted for meander = ',SIGMAy, ' m'
      write(10,109)'Maximum CR concentration at,tad,
&      'seconds after detection',data(kmax,3), 'ppm'

      write(*,*)'Wind speed for max CC concentration is',data(kmax,1)
      write(*,*)'Max CC conc. 2 min after detection is',data(kmax,3)
```

```
100 format(A60)
101 format(6F12.2)
102 format(7F10.2)
103 format(A60,1x,F10.2)
104 format(6A12/6A12/1x,78(' ')/)
105 format(7A10/1x,78(' '))
106 format(A50,1x,F10.3,1x,A10)
107 format(78(' ')/A42,1x,F7.2,A7/)
108 format(A25,F10.1,A25)
109 format(A28,F6.1,A25,F8.2,A4)
110 format(A60)
111 format(A15,A30,A35/A15,A30,A35/78(' '))
112 format(F15.2,2F30.2)
113 format(A28,F6.1,A45/)
114 format(A60,1x,A5)
115 format(5A14/5A14/1x,78(' ')/)
116 format(5F14.3)
117 format(2F14.3)
    end
```



### Computer Code Input Files

#### *3tcl2hct*

3 Ton Chlorine Release at Helper Cooling Tower

2721.6,70.9,946,288000,1570,239.1,305.6

1.0,6.0,0.1

364922,5700,435,3.5,40

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,1,3

#### *9tcl2hct*

9 Ton Chlorine Release at Helper Cooling Tower

8164.8,70.9,946,288000,1570,239.1,305.6

1.0,6.0,0.1

364922,5700,435,3.5,40

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,1,3

#### *1tcl2cr4*

1 Ton Chlorine Release at Crystal River 4/5

907.2,70.9,946,288000,1570,239.1,305.6

1.0,6.0,0.1

364922,5700,435,3.5,40

1097.2,0,26.46,6,0.0,3.0

1,2721.6,0.828,0.0

1.0,1.0e5,120.0,120.0,1,3

#### *173sohct*

17.3 Ton Sulfur Dioxide Release at Helper Cooling Tower

15694.6,64.1,1511,388461,1460,263.2,305.6

1.0,6.0,0.1

364922,5700,435,3.0,30

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,1,3

***50so2hct*****50 Ton Sulfur Dioxide Release at Helper Cooling Tower**

45360,64.1,1511,388461,1460,263.2,305.6

1.0,6.0,0.1

364922,5700,435,3.0,30

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,1,3

***14so2cr1*****1.4 Ton Sulfur Dioxide Release at CR 1/2**

1270.1,64.1,1511,388461,1460,263.2,305.6

1.0,6.0,0.1

364922,5700,435,3.0,30

228.6,0,26.46,6,55.75,3.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,1,3

***cl2hct25*****17 Ton Cl2 Release at HCT; isolation in 25 seconds**

15422.4,70.9,946,288000,1570,239.1,305.6

1.0,6.0,0.1

364922,5700,435,5,25

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,2,3

***cl2hct29*****17 Ton Cl2 Release at HCT; isolation in 29 seconds**

15422.4,70.9,946,288000,1570,239.1,305.6

1.0,6.0,0.1

364922,5700,435,5,29

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,2,3



*so2hct30*

50 Ton Sulfur Dioxide Release at HCT; 30 second isolation

45360,64.1,1511,388461,1460,263.2,305.6

1.0,6.0,0.1

364922,5700,435,2.4,30

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,2,3

*so2hct33*

50 Ton Sulfur Dioxide Release at HCT; 33 second isolation

45360,64.1,1511,388461,1460,263.2,305.6

1.0,6.0,0.1

364922,5700,435,2.4,33

1036.3,0,26.46,6,0.0,2.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,2,3

*so2cr130*

4.5 Ton SO2 Release at CR 1/2 with 30 second isolation

4082.4,64.1,1511,388461,1460,263.2,305.6

1.0,6.0,0.1

364922,5700,435,2.4,30

228.6,0,26.46,6,55.75,3.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,2,3

*so2cr230*

30 Ton SO2 Valve Release at CR 1/2 with 30 second isolation

0,64.1,1511,388461,1460,263.2,305.6

1.0,6.0,0.1

364922,5700,435,2.4,30

228.6,0,26.46,6,55.75,3.0

2,27216,2.53,12.83

1.0,1.0e5,120.0,120.0,2,3

30so2cr1

30 Ton Sulfur Dioxide Release at CR 1/2 w/out isolation

27216,64.1,1511,388461,1460,263.2,305.6

1.0,1.0,0.1

364922,5700,435,3.0,30

228.6,0,26.46,6,55.75,3.0

1,0.0,0.0,0.0

1.0,1.0e5,120.0,120.0,1,3



### Computer Code Validation and Verification

The FORTRAN computer code written for this calculation has been validated and verified according to Sargent & Lundy's General Engineering Standard GES-320.10, Rev. 3.

Preparer: Mark Handrick *Mark Handrick*

Date: 12/5/97

Reviewer: Chad J. Mitts *Chad J. Mitts*

Date: 12/5/97

Approver: Robert J. Peterson *Robert J. Peterson*

Date: 12/5/97

This validation will use MathCad to evaluate the equations shown in the main body of the calculation for a specific chemical release scenario. The solutions obtained in this validation will be compared to the output from the computer code, modeling the same scenario. Agreement between the computer code results and the MathCad validation will confirm that the computer code gives correct numerical results.

The validation case is representative of a 20 ton instantaneous chlorine release at a distance of 1000 meters from the control complex air intake. Automatic detection and isolation are modeled, with a detection concentration of 3.5 ppm and a 30 second isolation system response time. The computer code input and output file are provided following the Mathcad analysis.

$$M := 18144 \cdot \text{kg}$$

$$T_a := 305.6 \cdot \text{K}$$

$$T_b := 239.1 \cdot \text{K}$$

$$c_p := 946 \cdot \frac{\text{joule}}{\text{kg} \cdot \text{K}}$$

$$h_{fg} := 288000 \cdot \frac{\text{joule}}{\text{kg}}$$

$$\chi_i := c_p \cdot \frac{T_a - T_b}{h_{fg}}$$

$$\chi_i = 0.218$$

Code output gives 0.218

$$\rho_l := 1570 \cdot \frac{\text{kg}}{\text{m}^3}$$

$$Q := \chi_i \cdot M$$

$$Q = 3.963 \cdot 10^3 \cdot \text{kg}$$

Code output gives 3963.267 kg

$$P := (1.013 \cdot 10^5) \cdot \text{Pa}$$

$$R_g := 8.314 \cdot \frac{\text{joule}}{\text{mole} \cdot \text{K}}$$

$$M_w := 70.9 \cdot \frac{\text{g}}{\text{mole}} \cdot 1 \cdot \frac{\text{kg}}{1000 \cdot \text{g}}$$

$$\rho_v := \frac{P}{\left( \frac{R_g \cdot T_a}{M_w} \right)}$$

$$\rho_v = 2.827 \cdot \text{kg} \cdot \text{m}^{-3}$$

Calculate dispersion coefficients

$$\sigma_i := \left[ \frac{Q}{(2 \cdot \pi^3)^{0.5} \cdot \rho_v} \right]^{\frac{1}{3}}$$

$$\sigma_i = 5.626 \cdot \text{m}$$

Code output gives 5.63 m

Enter dispersion coefficients for Pasquill Stability Class F

$$\sigma_{hi} := 33.88 \cdot \text{m}$$

$$\sigma_{vi} := 13.95 \cdot m$$

$$\sigma_h := \sqrt{\sigma_{li}^2 + \sigma_{hi}^2}$$

$$\sigma_h = 34.344 \cdot m$$

Code output gives 34.35 m

$$\sigma_v := \sqrt{\sigma_{li}^2 + \sigma_{vi}^2}$$

$$\sigma_v = 15.042 \cdot m$$

Code output gives 15.04 m

$$\sigma_x := \sigma_h$$

$$\sigma_x = 34.344 \cdot m$$

$$\sigma_y := \sigma_h$$

$$\sigma_y = 34.344 \cdot m$$

$$\sigma_z := \sigma_v$$

$$\sigma_z = 15.042 \cdot m$$

Enter limiting wind speed of 3.0 m/s, as given in code output

$$U := \frac{3.0 \cdot m}{sec}$$

$$Mf := 9.592 \cdot \left( \frac{U}{1.0 \cdot \frac{m}{sec}} \right)^{-1.262}$$

$$Mf = 2.398$$

Code output gives 2.4

$$\sigma_{y800} := 27.6347 \cdot m$$

$$\Sigma y := (Mf - 1) \cdot \sigma_{y800} + \sigma_{hi}$$

$$\Sigma y = 72.503 \cdot m$$

Code output gives 72.507 m

$$L := 1000 \cdot m$$

$$WF := 2$$

The code output states that the release is detected at 290 seconds. This validation will calculate control complex concentrations before and after control complex isolation, to verify that the isolation logic employed in the computer code is correct.

Evaluate the concentrations at t = 310 seconds, or 20 seconds after detection.

$$t := 310 \cdot sec$$

$$x := L - U \cdot t$$

$$x = 70 \cdot m$$

Code output gives 70 m

$$y := 0 \cdot m$$

$$z := 0 \cdot m$$

$$z2 := 20 \cdot m$$

$$h := 0 \cdot m$$

Evaluate puff concentration using appropriate methodologies and choose minimum concentration.

$$\chi_{\text{puff1}} := \frac{Q}{(2 \cdot \pi)^{1.5} \cdot \sigma_x \cdot \sigma_y \cdot \sigma_z \cdot WF} \cdot e^{\left[ -0.5 \cdot \left( \frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} \right) \right]} \cdot \left[ e^{\left[ -0.5 \cdot \frac{(z-h)^2}{\sigma_z^2} \right]} + e^{\left[ -0.5 \cdot \frac{(z+h)^2}{\sigma_z^2} \right]} \right]$$

$$\chi_{\text{puff3}} := \frac{Q}{(2 \cdot \pi)^{1.5} \cdot \Sigma y \cdot \Sigma y \cdot \sigma_z} \cdot e^{\left[ -0.5 \cdot \left( \frac{x^2}{\Sigma y^2} + \frac{y^2}{\Sigma y^2} \right) \right]} \cdot \left[ e^{\left[ -0.5 \cdot \frac{(z-h)^2}{\sigma_z^2} \right]} + e^{\left[ -0.5 \cdot \frac{(z+h)^2}{\sigma_z^2} \right]} \right]$$

$$\chi_{\text{altpuf}} := \frac{Q}{(2 \cdot \pi) \cdot \sigma_x \cdot \sigma_y \cdot z^2} \cdot e^{\left[ -0.5 \cdot \left( \frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} \right) \right]}$$

$$\chi_{\text{puff1}} = 1.777 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\chi_{\text{puff3}} = 3.994 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\chi_{\text{altpuf}} = 3.35 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

Minimum puff concentration is  $\chi_{\text{puff1}}$

$$\text{PPM}_{\text{puff}} := \frac{\chi_{\text{puff1}}}{\rho_v} \cdot (1 \cdot 10)^6$$

$$\text{PPM}_{\text{puff}} = 628.643$$

Code output gives 628.69 ppm

$$\rho_a := \frac{P}{\left( \frac{R_g}{28.97 \cdot \frac{\text{kg}}{\text{mole}}} \cdot T_a \right)}$$

$$\rho_a = 1.155 \cdot 10^3 \cdot \text{kg} \cdot \text{m}^{-3}$$

$$V_o := (1 - \chi_i) \cdot \frac{M}{\rho_l}$$

$$V_o = 9.032 \cdot \text{m}^3$$

$$r_o := \left( \frac{V_o}{\pi} \right)^{\frac{1}{3}}$$

$$r_o = 1.422 \cdot \text{m}$$

Enter evaporative pool mass from previous time step

$$M_{\text{ep}} := 7451.301 \cdot \text{kg}$$

$$V_{\text{ep}} := \frac{M_{\text{ep}}}{\rho_l}$$

$$V_{\text{ep}} = 4.746 \cdot \text{m}^3$$

Code output gives 4.746 m^3

Compute surface area of evaporating pool

$$A := \pi \cdot \left[ r_o^2 + 2 \cdot t \cdot \left( 9.81 \cdot \frac{\text{m}}{\text{sec}^2} \cdot V_{\text{ep}} \cdot \frac{\rho_l - \rho_a}{\pi \cdot \rho_l} \right)^{\frac{1}{2}} \right] \quad A = 3.861 \cdot 10^3 \cdot \text{m}^2$$

Compute maximum surface area based on 1 cm spill thickness

$$A1 := (1 - \chi_i) \cdot \frac{M}{(\rho_l \cdot 0.01 \cdot m)}$$

$$A1 = 903.231 \cdot m^2$$

Code output gives 903.231  
m<sup>2</sup>

$$qr := 275 \cdot \frac{\text{cal}}{m^2 \cdot \text{sec}}$$

$$qc := 1.6 \cdot \frac{\text{cal}}{m^2 \cdot \text{sec} \cdot K} \cdot \left( \frac{U}{1.0 \cdot \frac{m}{\text{sec}}} \right)^{0.6} \cdot (Ta - Tb)$$

$$qd := 197 \cdot \frac{\text{cal}}{m^2 \cdot \text{sec}^{\frac{1}{2}} \cdot K} \cdot \frac{Ta - Tb}{t^{\frac{1}{2}}}$$

Calculate evaporation rate of spill at 310 seconds

$$\dot{m} := \frac{A1}{hfg} \cdot (qr + qc + qd) \cdot 4.186 \cdot \frac{\text{joule}}{\text{cal}}$$

$$\dot{m} = 16.079 \cdot \text{kg} \cdot \text{sec}^{-1}$$

Code output gives 16.079  
kg/s

Since the plume must travel at the wind velocity, no plume concentration will reach the intake until  $1000 \text{ (m)} / 3 \text{ (m/s)} = 333.3$  seconds. The code tracks the plume travel time, so the value of  $\dot{m}$  used in the plume concentration equations is set to zero.

$$\dot{m} := 0 \cdot \frac{\text{kg}}{\text{sec}}$$

$$\chi_{\text{plume1}} := \frac{\dot{m}}{2 \cdot \pi \cdot U \cdot \sigma_y \cdot \sigma_z \cdot WF} \cdot e^{\left[ -0.5 \cdot \left( \frac{y^2}{\sigma_y^2} \right) \right]} \cdot \left[ e^{\left[ -0.5 \cdot \frac{(z-h)^2}{\sigma_z^2} \right]} + e^{\left[ -0.5 \cdot \frac{(z+h)^2}{\sigma_z^2} \right]} \right]$$

$$\chi_{\text{plume3}} := \frac{\dot{m}}{2 \cdot \pi \cdot U \cdot \Sigma y \cdot \sigma_z} \cdot e^{\left[ -0.5 \cdot \left( \frac{y^2}{\Sigma y^2} \right) \right]} \cdot \left[ e^{\left[ -0.5 \cdot \frac{(z-h)^2}{\sigma_z^2} \right]} + e^{\left[ -0.5 \cdot \frac{(z+h)^2}{\sigma_z^2} \right]} \right]$$

$$\chi_{\text{plume1}} = 0 \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\chi_{\text{plume3}} = 0 \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\text{PPMplume} := \frac{\chi_{\text{plume3}}}{\rho_v} \cdot (1 \cdot 10)^6$$

$$\text{PPMplume} = 0$$

Code output gives 0 ppm

Total concentration at air intake is sum of puff and plume

$$Co := \text{PPMpuff} + \text{PPMplume}$$

$$Co = 628.643$$

Code output gives 628.69 ppm

Calculate control complex concentration before isolation

$$V := 400000 \cdot \text{ft}^3$$

$$W := 6000 \cdot \frac{\text{ft}^3}{\text{min}}$$

$$dt := 1 \cdot \text{sec}$$

Enter control complex concentration from previous time step

$$Crp := 0.67$$

$$Cr := Crp + (Co - Crp) \cdot \left(1 - e^{-W \cdot \frac{dt}{V}}\right)$$

$$Cr = 0.827$$

Code output gives 0.83 ppm

To examine the computer code isolation logic, concentrations will be evaluated at 350 seconds, or 30 seconds after control complex isolation.

$$t := 350 \cdot \text{sec}$$

$$x := L - U \cdot t$$

$$x = -50 \cdot \text{m}$$

Code output gives -50 m

$$y := 0 \cdot \text{m}$$

$$z := 0 \cdot \text{m}$$

$$z2 := 20 \cdot \text{m}$$

$$h := 0 \cdot \text{m}$$

Evaluate puff concentration using appropriate methodologies and choose minimum concentration.

$$\chi_{\text{puff1}} := \frac{Q}{(2 \cdot \pi)^{1.5} \cdot \sigma_x \cdot \sigma_y \cdot \sigma_z \cdot WF} \cdot e^{\left[-0.5 \cdot \left(\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right)\right]} \cdot \left[ e^{\left[-0.5 \cdot \frac{(z-h)^2}{\sigma_z^2}\right]} + e^{\left[-0.5 \cdot \frac{(z+h)^2}{\sigma_z^2}\right]} \right]$$

$$\chi_{\text{puff3}} := \frac{Q}{(2 \cdot \pi)^{1.5} \cdot \Sigma_y \cdot \Sigma_y \cdot \sigma_z} \cdot e^{\left[-0.5 \cdot \left(\frac{x^2}{\Sigma_y^2} + \frac{y^2}{\Sigma_y^2}\right)\right]} \cdot \left[ e^{\left[-0.5 \cdot \frac{(z-h)^2}{\sigma_z^2}\right]} + e^{\left[-0.5 \cdot \frac{(z+h)^2}{\sigma_z^2}\right]} \right]$$

$$\chi_{\text{altpuf}} := \frac{Q}{(2 \cdot \pi) \cdot \sigma_x \cdot \sigma_y \cdot z2} \cdot e^{\left[-0.5 \cdot \left(\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right)\right]}$$

$$\chi_{\text{puff1}} = 4.915 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\chi_{\text{puff3}} = 5.018 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\chi_{\text{altpuf}} = 9.266 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

Minimum puff concentration is  $\chi_{\text{puff1}}$

$$\text{PPM}_{\text{puff}} := \frac{\chi_{\text{puff1}}}{\rho_v} \cdot (1 \cdot 10)^6 \quad \text{PPM}_{\text{puff}} = 1.739 \cdot 10^3 \quad \text{Code output gives 1738.49 ppm}$$

$$t := 350 \cdot \text{sec}$$

Enter evaporative pool mass from previous time step

$$M_{\text{ep}} := 6819.714 \cdot \text{kg}$$

$$V_{\text{ep}} := \frac{M_{\text{ep}}}{\rho_l} \quad V_{\text{ep}} = 4.344 \cdot \text{m}^3 \quad \text{Code output gives 4.344 m}^3$$

Compute surface area of evaporating pool

$$A := \pi \cdot \left[ r_o^2 + 2 \cdot t \cdot \left( 9.81 \cdot \frac{\text{m}}{\text{sec}^2} \cdot V_{\text{ep}} \cdot \frac{\rho_l - \rho_a}{\pi \cdot \rho_l} \right)^{\frac{1}{2}} \right] \quad A = 3.861 \cdot 10^3 \cdot \text{m}^2$$

Compute maximum surface area based on 1 cm spill thickness

$$A1 := (1 - \chi_i) \cdot \frac{M}{(\rho_l \cdot 0.01 \cdot \text{m})} \quad A1 = 903.231 \cdot \text{m}^2 \quad \text{Code gives 903.231 m}^2$$

$$q_r := 275 \cdot \frac{\text{cal}}{\text{m}^2 \cdot \text{sec}}$$

$$q_c := 1.6 \cdot \frac{\text{cal}}{\text{m}^2 \cdot \text{sec} \cdot \text{K}} \cdot \left( \frac{U}{1.0 \cdot \frac{\text{m}}{\text{sec}}} \right)^{0.6} \cdot (T_a - T_b)$$

$$q_d := 197 \cdot \frac{\text{cal}}{\text{m}^2 \cdot \text{sec}^{\frac{1}{2}} \cdot \text{K}} \cdot \frac{T_a - T_b}{t^{\frac{1}{2}}}$$

Calculate evaporation rate of spill at 350 seconds

$$\dot{m}_{\text{dot}} := \frac{A1}{h_{\text{fg}}} \cdot (q_r + q_c + q_d) \cdot 4.186 \cdot \frac{\text{joule}}{\text{cal}} \quad \dot{m}_{\text{dot}} = 15.504 \cdot \text{kg} \cdot \text{sec}^{-1} \quad \text{Code gives 15.504 kg/s}$$

At 350 seconds, the plume concentration has reached the air intake. The code will account for the evaporation rate which contributed to the plume before traveling towards the control complex intake. At a wind speed of 3 m/s, the appropriate evaporation rate is that which occurred at 16 seconds.

$$\dot{m} := 29.179 \cdot \frac{\text{kg}}{\text{sec}}$$

$$\chi_{\text{plume1}} := \frac{\dot{m}}{2 \cdot \pi \cdot U \cdot \sigma_y \cdot \sigma_z \cdot W} \cdot e^{\left[ -0.5 \cdot \left( \frac{y^2}{\sigma_y^2} \right) \right]} \cdot \left[ e^{\left[ -0.5 \cdot \frac{(z-h)^2}{\sigma_z^2} \right]} + e^{\left[ -0.5 \cdot \frac{(z+h)^2}{\sigma_z^2} \right]} \right]$$

$$\chi_{\text{plume3}} := \frac{\dot{m}}{2 \cdot \pi \cdot U \cdot \Sigma_y \cdot \sigma_z} \cdot e^{\left[ -0.5 \cdot \left( \frac{y^2}{\Sigma_y^2} \right) \right]} \cdot \left[ e^{\left[ -0.5 \cdot \frac{(z-h)^2}{\sigma_z^2} \right]} + e^{\left[ -0.5 \cdot \frac{(z+h)^2}{\sigma_z^2} \right]} \right]$$

$$\chi_{\text{plume1}} = 2.997 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\chi_{\text{plume3}} = 2.839 \cdot 10^{-3} \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\text{PPMplume} := \frac{\chi_{\text{plume3}}}{\rho_v} \cdot (1 \cdot 10)^6 \quad \text{PPMplume} = 1.004 \cdot 10^3 \quad \text{Code output gives 1004.02 ppm}$$

Total concentration at air intake is sum of puff and plume

$$C_o := \text{PPMpuff} + \text{PPMplume} \quad C_o = 2.743 \cdot 10^3 \quad \text{Code output gives 2742.51 ppm}$$

Calculate control complex concentration after isolation

$$V := 400000 \cdot \text{ft}^3$$

$$W := 500 \cdot \frac{\text{ft}^3}{\text{min}}$$

$$dt := 1 \cdot \text{sec}$$

Enter control complex concentration from previous time step

$$C_{rp} := 5.45$$

$$C_r := C_{rp} + (C_o - C_{rp}) \cdot \left( 1 - e^{-\frac{W \cdot dt}{V}} \right) \quad C_r = 5.507 \quad \text{Code output gives 5.50 ppm}$$

The very close agreement between the MathCad analysis and the computer code output demonstrates the validity of the computer code developed in this calculation.



## Computer Code Validation Input/Output Files

Validation Case: 20 Ton Chlorine Release at 1000 meters

18144.0,70.9,946,288000,1570,239.1,305.6

1.0,3.0,0.1

400000,6000,500,3.5,30

1000.0,0,20.0,6,0.0,2.0

1,0,0,0,0,0

1.0,1.0e5,120.0,120.0,2,3

Validation Case: 20 Ton Chlorine Release at 1000 meters

Output file is validatn.out

Accident scenario is tank failure

Mass of spill, kg = 18144.00

Mass available for leakage, kg = 0.00

Valve vapor leakage rate, kg/s = 0.00

Valve liquid leakage rate, kg/s = 0.00

Molecular weight of chemical = 70.90

Latent heat of chemical, J/kg = 288000.00

Specific heat of chemical, J/kg-K = 946.00

Liquid density of chemical, kg/m<sup>3</sup> = 1570.00

Heavier than air model for Gaussian distribution; h = z = 0

NUREG/CR-3786 concentration calculation performed  
assuming uniform vertical distribution at intake;

Minimum intake concentration between two models is used

Detection at intake

Detection concentration, ppm = 3.50

Ambient temperature, K = 305.60

Boiling temperature, K = 239.10

Minimum wind speed, m/sec = 1.00

Maximum wind speed, m/sec = 3.00

Wind speed increment, m/sec = 0.10

Atmospheric stability class is type 6.00

1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G

Ventilation rate before isolation, cfm = 6000.00

Infiltration rate after isolation, cfm = 500.00

Distance from spill to CR intake, m = 1000.00

Building wake factor = 2.00

Maximum area of spill; 0 if no berm, ft<sup>2</sup> = 0.00

Dispersion coeff for initial flashing, m = 5.63

Unadjusted horizontal dispersion coef., m = 33.88

Unadjusted vertical dispersion coef., m = 13.95

Horizontal dispersion coefficient, m = 34.35

Vertical dispersion coefficient, m = 15.04

Above ground elevation of CR intake, m = 0.00

Above ground elevation of spill, m = 0.00

Maximum time, sec = 100000.00

Time increment, sec = 1.00  
 Time after detection for max CR conc., sec = 120.00  
 Problem stopped at 120.0 seconds after max Cr

Maximum CR concentration at 120.0 seconds after detection versus wind speed

Wind speed, U (m/sec)	Intake Concentration, Co (ppm)	Control Room Concentration, Cr (ppm)
1.00	864.48	1.37
1.10	1321.06	1.51
1.20	2113.03	1.81
1.30	2388.02	2.12
1.40	2515.68	2.41
1.50	2301.22	2.73
1.60	2088.58	2.95
1.70	1677.55	3.12
1.80	1320.54	3.17
1.90	1087.59	3.31
2.00	963.25	3.38
2.10	933.99	3.63
2.20	911.80	4.12
2.30	908.16	4.27
2.40	900.06	4.80
2.50	903.13	5.01
2.60	895.86	5.52
2.70	898.55	5.70
2.80	896.24	6.29
2.90	893.90	6.62
3.00	895.98	7.05

Time history for limiting wind speed of 3.00 m/sec

time (sec)	x (meters)	Chi(puff) (ppm)	Chi(plume) (ppm)	Co (ppm)	Cr (ppm)
270.00	190.00	0.00	0.00	0.00	0.00
271.00	187.00	0.00	0.00	0.00	0.00
272.00	184.00	0.00	0.00	0.00	0.00
273.00	181.00	0.00	0.00	0.00	0.00
274.00	178.00	0.01	0.00	0.01	0.00
275.00	175.00	0.01	0.00	0.01	0.00
276.00	172.00	0.02	0.00	0.02	0.00
277.00	169.00	0.03	0.00	0.03	0.00
278.00	166.00	0.04	0.00	0.04	0.00
279.00	163.00	0.06	0.00	0.06	0.00
280.00	160.00	0.10	0.00	0.10	0.00
281.00	157.00	0.15	0.00	0.15	0.00

282.00	154.00	0.22	0.00	0.22	0.00
283.00	151.00	0.32	0.00	0.32	0.00
284.00	148.00	0.47	0.00	0.47	0.00
285.00	145.00	0.68	0.00	0.68	0.00
286.00	142.00	0.98	0.00	0.98	0.00
287.00	139.00	1.39	0.00	1.39	0.00
288.00	136.00	1.98	0.00	1.98	0.00
289.00	133.00	2.78	0.00	2.78	0.00
290.00	130.00	3.89	0.00	3.89	0.00
291.00	127.00	5.39	0.00	5.39	0.00
292.00	124.00	7.42	0.00	7.42	0.01
293.00	121.00	10.13	0.00	10.13	0.01
294.00	118.00	13.73	0.00	13.73	0.01
295.00	115.00	18.46	0.00	18.46	0.02
296.00	112.00	24.63	0.00	24.63	0.02
297.00	109.00	32.62	0.00	32.62	0.03
298.00	106.00	42.88	0.00	42.88	0.04
299.00	103.00	55.93	0.00	55.93	0.06
300.00	100.00	72.40	0.00	72.40	0.07
301.00	97.00	93.01	0.00	93.01	0.10
302.00	94.00	118.58	0.00	118.58	0.13
303.00	91.00	150.02	0.00	150.02	0.16
304.00	88.00	188.36	0.00	188.36	0.21
305.00	85.00	234.70	0.00	234.70	0.27
306.00	82.00	290.21	0.00	290.21	0.34
307.00	79.00	356.14	0.00	356.14	0.43
308.00	76.00	433.72	0.00	433.72	0.54
309.00	73.00	524.18	0.00	524.18	0.67
310.00	70.00	628.69	0.00	628.69	0.83
311.00	67.00	748.32	0.00	748.32	1.01
312.00	64.00	883.93	0.00	883.93	1.24
313.00	61.00	1036.19	0.00	1036.19	1.49
314.00	58.00	1205.44	0.00	1205.44	1.79
315.00	55.00	1391.69	0.00	1391.69	2.14
316.00	52.00	1594.50	0.00	1594.50	2.54
317.00	49.00	1791.48	0.00	1791.48	2.99
318.00	46.00	1840.70	0.00	1840.70	3.45
319.00	43.00	1888.04	0.00	1888.04	3.92
320.00	40.00	1933.29	0.00	1933.29	3.96
321.00	37.00	1976.23	0.00	1976.23	4.00
322.00	34.00	2016.67	0.00	2016.67	4.04
323.00	31.00	2054.42	0.00	2054.42	4.08
324.00	28.00	2089.30	0.00	2089.30	4.13
325.00	25.00	2121.13	0.00	2121.13	4.17
326.00	22.00	2149.77	0.00	2149.77	4.22
327.00	19.00	2175.06	0.00	2175.06	4.26
328.00	16.00	2196.89	0.00	2196.89	4.31
329.00	13.00	2215.14	0.00	2215.14	4.35
330.00	10.00	2229.73	0.00	2229.73	4.40
331.00	7.00	2240.57	0.00	2240.57	4.45
332.00	4.00	2247.61	0.00	2247.61	4.49
333.00	1.00	2250.82	0.00	2250.82	4.54
334.00	-2.00	2250.18	43.15	2293.33	4.59

335.00	-5.00	2245.69	269.71	2515.40	4.64
336.00	-8.00	2237.38	355.97	2593.34	4.69
337.00	-11.00	2225.28	427.88	2653.16	4.75
338.00	-14.00	2209.46	490.99	2700.45	4.80
339.00	-17.00	2190.01	548.07	2738.08	4.86
340.00	-20.00	2167.01	600.69	2767.70	4.92
341.00	-23.00	2140.59	649.84	2790.43	4.98
342.00	-26.00	2110.87	696.18	2807.05	5.04
343.00	-29.00	2078.00	740.18	2818.18	5.09
344.00	-32.00	2042.15	782.18	2824.33	5.15
345.00	-35.00	2003.48	822.46	2825.94	5.21
346.00	-38.00	1962.18	861.22	2823.40	5.27
347.00	-41.00	1918.45	898.63	2817.08	5.33
348.00	-44.00	1872.48	934.83	2807.31	5.39
349.00	-47.00	1824.49	969.93	2794.42	5.45
350.00	-50.00	1738.49	1004.02	2742.51	5.50
351.00	-53.00	1525.10	1037.19	2562.29	5.56
352.00	-56.00	1327.74	1069.51	2397.25	5.61
353.00	-59.00	1147.13	1101.03	2248.16	5.65
354.00	-62.00	983.56	1131.81	2115.37	5.70
355.00	-65.00	836.90	1161.89	1998.79	5.74
356.00	-68.00	706.70	1191.31	1898.01	5.78
357.00	-71.00	592.22	1220.11	1812.33	5.82
358.00	-74.00	492.52	1248.31	1740.83	5.85
359.00	-77.00	406.48	1275.96	1682.44	5.89
360.00	-80.00	332.93	1303.07	1636.00	5.92
361.00	-83.00	270.61	1329.66	1600.28	5.95
362.00	-86.00	218.29	1335.54	1553.83	5.99
363.00	-89.00	174.74	1316.09	1490.83	6.02
364.00	-92.00	138.82	1297.62	1436.44	6.05
365.00	-95.00	109.45	1280.05	1389.49	6.08
366.00	-98.00	85.63	1263.31	1348.94	6.10
367.00	-101.00	66.49	1247.33	1313.82	6.13
368.00	-104.00	51.23	1232.07	1283.30	6.16
369.00	-107.00	39.18	1217.47	1256.65	6.18
370.00	-110.00	29.73	1203.47	1233.21	6.21
371.00	-113.00	22.39	1190.05	1212.45	6.23
372.00	-116.00	16.74	1177.17	1193.90	6.26
373.00	-119.00	12.41	1164.78	1177.19	6.28
374.00	-122.00	9.14	1152.86	1162.00	6.31
375.00	-125.00	6.67	1141.38	1148.05	6.33
376.00	-128.00	4.84	1130.31	1135.15	6.35
377.00	-131.00	3.48	1119.63	1123.11	6.38
378.00	-134.00	2.49	1109.31	1111.80	6.40
379.00	-137.00	1.76	1099.35	1101.11	6.42
380.00	-140.00	1.24	1089.70	1090.94	6.45
381.00	-143.00	0.86	1080.37	1081.24	6.47
382.00	-146.00	0.60	1071.33	1071.93	6.49
383.00	-149.00	0.41	1062.57	1062.98	6.51
384.00	-152.00	0.28	1054.07	1054.35	6.53
385.00	-155.00	0.19	1045.83	1046.02	6.56
386.00	-158.00	0.13	1037.82	1037.95	6.58
387.00	-161.00	0.08	1030.04	1030.13	6.60

388.00	-164.00	0.06	1022.48	1022.54	6.62
389.00	-167.00	0.04	1015.13	1015.16	6.64
390.00	-170.00	0.02	1007.97	1007.99	6.66
391.00	-173.00	0.02	1001.00	1001.02	6.68
392.00	-176.00	0.01	994.21	994.22	6.70
393.00	-179.00	0.01	987.60	987.61	6.72
394.00	-182.00	0.00	981.15	981.16	6.74
395.00	-185.00	0.00	974.86	974.87	6.76
396.00	-188.00	0.00	968.73	968.73	6.78
397.00	-191.00	0.00	962.74	962.74	6.80
398.00	-194.00	0.00	956.89	956.89	6.82
399.00	-197.00	0.00	951.18	951.18	6.84
400.00	-200.00	0.00	945.60	945.60	6.86
401.00	-203.00	0.00	940.14	940.14	6.88
402.00	-206.00	0.00	934.81	934.81	6.90
403.00	-209.00	0.00	929.59	929.59	6.92
404.00	-212.00	0.00	924.48	924.48	6.94
405.00	-215.00	0.00	919.48	919.48	6.96
406.00	-218.00	0.00	914.59	914.59	6.98
407.00	-221.00	0.00	909.79	909.79	7.00
408.00	-224.00	0.00	905.10	905.10	7.02
409.00	-227.00	0.00	900.49	900.49	7.03
410.00	-230.00	0.00	895.98	895.98	7.05
411.00	-233.00	0.00	891.56	891.56	7.07
412.00	-236.00	0.00	887.22	887.22	7.09
413.00	-239.00	0.00	882.97	882.97	7.11
414.00	-242.00	0.00	878.80	878.80	7.13
415.00	-245.00	0.00	874.70	874.70	7.14
416.00	-248.00	0.00	870.68	870.68	7.16
417.00	-251.00	0.00	866.73	866.73	7.18
418.00	-254.00	0.00	862.85	862.85	7.20
419.00	-257.00	0.00	859.04	859.04	7.22
420.00	-260.00	0.00	855.30	855.30	7.23
421.00	-263.00	0.00	851.62	851.62	7.25
422.00	-266.00	0.00	848.00	848.00	7.27
423.00	-269.00	0.00	844.45	844.45	7.29
424.00	-272.00	0.00	840.95	840.95	7.30
425.00	-275.00	0.00	837.52	837.52	7.32
426.00	-278.00	0.00	834.14	834.14	7.34
427.00	-281.00	0.00	830.81	830.81	7.35
428.00	-284.00	0.00	827.54	827.54	7.37
429.00	-287.00	0.00	824.32	824.32	7.39
430.00	-290.00	0.00	821.15	821.15	7.41
431.00	-293.00	0.00	818.02	818.02	7.42
432.00	-296.00	0.00	814.95	814.95	7.44
433.00	-299.00	0.00	811.92	811.92	7.46
434.00	-302.00	0.00	808.94	808.94	7.47
435.00	-305.00	0.00	806.01	806.01	7.49
436.00	-308.00	0.00	803.11	803.11	7.51
437.00	-311.00	0.00	800.26	800.26	7.52
438.00	-314.00	0.00	797.45	797.45	7.54
439.00	-317.00	0.00	794.68	794.68	7.56
440.00	-320.00	0.00	791.95	791.95	7.57

441.00	-323.00	0.00	789.26	789.26	7.59
442.00	-326.00	0.00	786.60	786.60	7.60
443.00	-329.00	0.00	783.98	783.98	7.62
444.00	-332.00	0.00	781.40	781.40	7.64
445.00	-335.00	0.00	778.85	778.85	7.65
446.00	-338.00	0.00	776.34	776.34	7.67
447.00	-341.00	0.00	773.86	773.86	7.68
448.00	-344.00	0.00	771.41	771.41	7.70
449.00	-347.00	0.00	769.00	769.00	7.72
450.00	-350.00	0.00	766.62	766.62	7.73
451.00	-353.00	0.00	764.26	764.26	7.75
452.00	-356.00	0.00	761.94	761.94	7.76
453.00	-359.00	0.00	759.65	759.65	7.78
454.00	-362.00	0.00	757.38	757.38	7.79
455.00	-365.00	0.00	755.14	755.14	7.81
456.00	-368.00	0.00	752.93	752.93	7.83
457.00	-371.00	0.00	750.75	750.75	7.84
458.00	-374.00	0.00	748.60	748.60	7.86
459.00	-377.00	0.00	746.47	746.47	7.87
460.00	-380.00	0.00	744.36	744.36	7.89
461.00	-383.00	0.00	742.28	742.28	7.90
462.00	-386.00	0.00	740.23	740.23	7.92
463.00	-389.00	0.00	738.19	738.19	7.93
464.00	-392.00	0.00	736.19	736.19	7.95
465.00	-395.00	0.00	734.20	734.20	7.96
466.00	-398.00	0.00	732.24	732.24	7.98
467.00	-401.00	0.00	730.30	730.30	7.99
468.00	-404.00	0.00	728.38	728.38	8.01
469.00	-407.00	0.00	726.48	726.48	8.02
470.00	-410.00	0.00	724.61	724.61	8.04
471.00	-413.00	0.00	722.75	722.75	8.05
472.00	-416.00	0.00	720.92	720.92	8.07
473.00	-419.00	0.00	719.10	719.10	8.08
474.00	-422.00	0.00	717.31	717.31	8.10
475.00	-425.00	0.00	715.53	715.53	8.11
476.00	-428.00	0.00	713.77	713.77	8.13
477.00	-431.00	0.00	712.03	712.03	8.14
478.00	-434.00	0.00	710.31	710.31	8.16
479.00	-437.00	0.00	708.61	708.61	8.17
480.00	-440.00	0.00	706.92	706.92	8.19
481.00	-443.00	0.00	705.25	705.25	8.20
482.00	-446.00	0.00	703.60	703.60	8.22
483.00	-449.00	0.00	701.96	701.96	8.23
484.00	-452.00	0.00	700.35	700.35	8.24
485.00	-455.00	0.00	698.74	698.74	8.26
486.00	-458.00	0.00	697.16	697.16	8.27
487.00	-461.00	0.00	695.59	695.59	8.29
488.00	-464.00	0.00	694.03	694.03	8.30
489.00	-467.00	0.00	692.49	692.49	8.32
490.00	-470.00	0.00	690.96	690.96	8.33
491.00	-473.00	0.00	689.45	689.45	8.34
492.00	-476.00	0.00	687.95	687.95	8.36
493.00	-479.00	0.00	686.47	686.47	8.37

494.00	-482.00	0.00	685.00	685.00	8.39
495.00	-485.00	0.00	683.55	683.55	8.40
496.00	-488.00	0.00	682.11	682.11	8.41
497.00	-491.00	0.00	680.68	680.68	8.43
498.00	-494.00	0.00	679.26	679.26	8.44
499.00	-497.00	0.00	677.86	677.86	8.46
500.00	-500.00	0.00	676.47	676.47	8.47
501.00	-503.00	0.00	675.09	675.09	8.48
502.00	-506.00	0.00	673.73	673.73	8.50
503.00	-509.00	0.00	672.37	672.37	8.51
504.00	-512.00	0.00	671.03	671.03	8.53
505.00	-515.00	0.00	669.70	669.70	8.54
506.00	-518.00	0.00	668.39	668.39	8.55
507.00	-521.00	0.00	667.08	667.08	8.57
508.00	-524.00	0.00	665.79	665.79	8.58
509.00	-527.00	0.00	664.50	664.50	8.59
510.00	-530.00	0.00	663.23	663.23	8.61
511.00	-533.00	0.00	661.97	661.97	8.62
512.00	-536.00	0.00	660.72	660.72	8.64
513.00	-539.00	0.00	659.48	659.48	8.65
514.00	-542.00	0.00	658.25	658.25	8.66
515.00	-545.00	0.00	657.03	657.03	8.68
516.00	-548.00	0.00	655.82	655.82	8.69
517.00	-551.00	0.00	654.61	654.61	8.70
518.00	-554.00	0.00	653.42	653.42	8.72
519.00	-557.00	0.00	652.24	652.24	8.73
520.00	-560.00	0.00	651.07	651.07	8.74
521.00	-563.00	0.00	649.91	649.91	8.76
522.00	-566.00	0.00	648.76	648.76	8.77
523.00	-569.00	0.00	647.61	647.61	8.78
524.00	-572.00	0.00	646.48	646.48	8.80
525.00	-575.00	0.00	645.36	645.36	8.81
526.00	-578.00	0.00	644.24	644.24	8.82
527.00	-581.00	0.00	643.13	643.13	8.84
528.00	-584.00	0.00	642.03	642.03	8.85
529.00	-587.00	0.00	640.94	640.94	8.86
530.00	-590.00	0.00	639.86	639.86	8.88

Initial flashing fraction = 0.218

Initial flashing mass = 3963.267 kg

Release detected at 290.000 seconds

Adjusted elevation of CR intake for Gaussian model, m = 0.00

Adjusted elev. of CR intake for NUREG/CR-3786 model, m = 20.00

Adjusted elevation of spill for Gaussian model, m = 0.00

Arrival time of plume at intake 333.333 seconds

Wind speed for max CC concentration is 3.000 m/sec

Meander factor at this wind speed is 2.40

Hor. coeff. adjusted for meander = 72.507 m

Maximum CR concentration at 120.0 seconds after detection 7.05 ppm

Output file is validatn.sar

time (sec)	Mass (kg)	Volume (m <sup>3</sup> )	dMdt (kg/s)	Area (m <sup>2</sup> )
270.000	8091.514	5.154	16.777	903.231
271.000	8074.756	5.143	16.758	903.231
272.000	8058.017	5.132	16.739	903.231
273.000	8041.297	5.122	16.720	903.231
274.000	8024.596	5.111	16.701	903.231
275.000	8007.915	5.101	16.682	903.231
276.000	7991.252	5.090	16.663	903.231
277.000	7974.607	5.079	16.644	903.231
278.000	7957.982	5.069	16.626	903.231
279.000	7941.375	5.058	16.607	903.231
280.000	7924.786	5.048	16.589	903.231
281.000	7908.215	5.037	16.570	903.231
282.000	7891.663	5.027	16.552	903.231
283.000	7875.129	5.016	16.534	903.231
284.000	7858.613	5.005	16.516	903.231
285.000	7842.115	4.995	16.498	903.231
286.000	7825.634	4.984	16.480	903.231
287.000	7809.172	4.974	16.463	903.231
288.000	7792.727	4.964	16.445	903.231
289.000	7776.299	4.953	16.427	903.231
290.000	7759.889	4.943	16.410	903.231
291.000	7743.497	4.932	16.393	903.231
292.000	7727.121	4.922	16.375	903.231
293.000	7710.763	4.911	16.358	903.231
294.000	7694.422	4.901	16.341	903.231
295.000	7678.098	4.891	16.324	903.231
296.000	7661.791	4.880	16.307	903.231
297.000	7645.501	4.870	16.290	903.231
298.000	7629.227	4.859	16.274	903.231
299.000	7612.970	4.849	16.257	903.231
300.000	7596.730	4.839	16.240	903.231
301.000	7580.506	4.828	16.224	903.231
302.000	7564.299	4.818	16.207	903.231
303.000	7548.108	4.808	16.191	903.231
304.000	7531.934	4.797	16.175	903.231
305.000	7515.775	4.787	16.159	903.231
306.000	7499.633	4.777	16.142	903.231
307.000	7483.506	4.767	16.126	903.231
308.000	7467.396	4.756	16.110	903.231
309.000	7451.301	4.746	16.095	903.231
310.000	7435.222	4.736	16.079	903.231
311.000	7419.159	4.726	16.063	903.231
312.000	7403.112	4.715	16.047	903.231
313.000	7387.080	4.705	16.032	903.231
314.000	7371.064	4.695	16.016	903.231
315.000	7355.063	4.685	16.001	903.231
316.000	7339.077	4.675	15.986	903.231



317.000	7323.107	4.664	15.970	903.231
318.000	7307.152	4.654	15.955	903.231
319.000	7291.212	4.644	15.940	903.231
320.000	7275.287	4.634	15.925	903.231
321.000	7259.377	4.624	15.910	903.231
322.000	7243.482	4.614	15.895	903.231
323.000	7227.602	4.604	15.880	903.231
324.000	7211.736	4.593	15.865	903.231
325.000	7195.886	4.583	15.851	903.231
326.000	7180.050	4.573	15.836	903.231
327.000	7164.228	4.563	15.821	903.231
328.000	7148.421	4.553	15.807	903.231
329.000	7132.629	4.543	15.793	903.231
330.000	7116.851	4.533	15.778	903.231
331.000	7101.087	4.523	15.764	903.231
332.000	7085.337	4.513	15.750	903.231
333.000	7069.602	4.503	15.735	903.231
334.000	7053.880	4.493	15.721	903.231
335.000	7038.173	4.483	15.707	903.231
336.000	7022.480	4.473	15.693	903.231
337.000	7006.801	4.463	15.679	903.231
338.000	6991.135	4.453	15.665	903.231
339.000	6975.484	4.443	15.652	903.231
340.000	6959.846	4.433	15.638	903.231
341.000	6944.222	4.423	15.624	903.231
342.000	6928.611	4.413	15.611	903.231
343.000	6913.014	4.403	15.597	903.231
344.000	6897.431	4.393	15.583	903.231
345.000	6881.861	4.383	15.570	903.231
346.000	6866.304	4.373	15.557	903.231
347.000	6850.761	4.364	15.543	903.231
348.000	6835.231	4.354	15.530	903.231
349.000	6819.714	4.344	15.517	903.231
350.000	6804.210	4.334	15.504	903.231
351.000	6788.719	4.324	15.491	903.231
352.000	6773.242	4.314	15.478	903.231
353.000	6757.777	4.304	15.465	903.231
354.000	6742.326	4.294	15.452	903.231
355.000	6726.887	4.285	15.439	903.231
356.000	6711.461	4.275	15.426	903.231
357.000	6696.048	4.265	15.413	903.231
358.000	6680.648	4.255	15.400	903.231
359.000	6665.260	4.245	15.388	903.231
360.000	6649.885	4.236	15.375	903.231
361.000	6634.523	4.226	15.363	903.231
362.000	6619.173	4.216	15.350	903.231
363.000	6603.835	4.206	15.338	903.231
364.000	6588.510	4.197	15.325	903.231
365.000	6573.197	4.187	15.313	903.231
366.000	6557.897	4.177	15.300	903.231
367.000	6542.608	4.167	15.288	903.231
368.000	6527.332	4.158	15.276	903.231
369.000	6512.069	4.148	15.264	903.231

370.000	6496.817	4.138	15.252	903.231
371.000	6481.577	4.128	15.240	903.231
372.000	6466.349	4.119	15.228	903.231
373.000	6451.134	4.109	15.216	903.231
374.000	6435.930	4.099	15.204	903.231
375.000	6420.738	4.090	15.192	903.231
376.000	6405.558	4.080	15.180	903.231
377.000	6390.390	4.070	15.168	903.231
378.000	6375.233	4.061	15.157	903.231
379.000	6360.088	4.051	15.145	903.231
380.000	6344.955	4.041	15.133	903.231
381.000	6329.833	4.032	15.122	903.231
382.000	6314.723	4.022	15.110	903.231
383.000	6299.624	4.012	15.099	903.231
384.000	6284.537	4.003	15.087	903.231
385.000	6269.461	3.993	15.076	903.231
386.000	6254.396	3.984	15.064	903.231
387.000	6239.343	3.974	15.053	903.231
388.000	6224.301	3.965	15.042	903.231
389.000	6209.271	3.955	15.031	903.231
390.000	6194.251	3.945	15.019	903.231
391.000	6179.243	3.936	15.008	903.231
392.000	6164.246	3.926	14.997	903.231
393.000	6149.260	3.917	14.986	903.231
394.000	6134.284	3.907	14.975	903.231
395.000	6119.320	3.898	14.964	903.231
396.000	6104.367	3.888	14.953	903.231
397.000	6089.425	3.879	14.942	903.231
398.000	6074.493	3.869	14.932	903.231
399.000	6059.572	3.860	14.921	903.231
400.000	6044.662	3.850	14.910	903.231
401.000	6029.763	3.841	14.899	903.231
402.000	6014.875	3.831	14.889	903.231
403.000	5999.997	3.822	14.878	903.231
404.000	5985.130	3.812	14.867	903.231
405.000	5970.273	3.803	14.857	903.231
406.000	5955.427	3.793	14.846	903.231
407.000	5940.591	3.784	14.836	903.231
408.000	5925.766	3.774	14.825	903.231
409.000	5910.951	3.765	14.815	903.231
410.000	5896.147	3.756	14.804	903.231
411.000	5881.353	3.746	14.794	903.231
412.000	5866.569	3.737	14.784	903.231
413.000	5851.796	3.727	14.773	903.231
414.000	5837.032	3.718	14.763	903.231
415.000	5822.279	3.708	14.753	903.231
416.000	5807.536	3.699	14.743	903.231
417.000	5792.803	3.690	14.733	903.231
418.000	5778.081	3.680	14.723	903.231
419.000	5763.368	3.671	14.713	903.231
420.000	5748.665	3.662	14.703	903.231
421.000	5733.973	3.652	14.693	903.231
422.000	5719.290	3.643	14.683	903.231



423.000	5704.617	3.634	14.673	903.231
424.000	5689.954	3.624	14.663	903.231
425.000	5675.301	3.615	14.653	903.231
426.000	5660.657	3.606	14.643	903.231
427.000	5646.024	3.596	14.634	903.231
428.000	5631.400	3.587	14.624	903.231
429.000	5616.786	3.578	14.614	903.231
430.000	5602.181	3.568	14.605	903.231
431.000	5587.586	3.559	14.595	903.231
432.000	5573.001	3.550	14.585	903.231
433.000	5558.425	3.540	14.576	903.231
434.000	5543.859	3.531	14.566	903.231
435.000	5529.302	3.522	14.557	903.231
436.000	5514.755	3.513	14.547	903.231
437.000	5500.217	3.503	14.538	903.231
438.000	5485.689	3.494	14.528	903.231
439.000	5471.170	3.485	14.519	903.231
440.000	5456.660	3.476	14.510	903.231
441.000	5442.160	3.466	14.500	903.231
442.000	5427.669	3.457	14.491	903.231
443.000	5413.187	3.448	14.482	903.231
444.000	5398.714	3.439	14.473	903.231
445.000	5384.250	3.429	14.464	903.231
446.000	5369.796	3.420	14.454	903.231
447.000	5355.351	3.411	14.445	903.231
448.000	5340.914	3.402	14.436	903.231
449.000	5326.487	3.393	14.427	903.231
450.000	5312.069	3.383	14.418	903.231
451.000	5297.660	3.374	14.409	903.231
452.000	5283.260	3.365	14.400	903.231
453.000	5268.869	3.356	14.391	903.231
454.000	5254.486	3.347	14.382	903.231
455.000	5240.113	3.338	14.373	903.231
456.000	5225.748	3.329	14.365	903.231
457.000	5211.393	3.319	14.356	903.231
458.000	5197.046	3.310	14.347	903.231
459.000	5182.707	3.301	14.338	903.231
460.000	5168.378	3.292	14.330	903.231
461.000	5154.057	3.283	14.321	903.231
462.000	5139.745	3.274	14.312	903.231
463.000	5125.441	3.265	14.303	903.231
464.000	5111.146	3.256	14.295	903.231
465.000	5096.860	3.246	14.286	903.231
466.000	5082.582	3.237	14.278	903.231
467.000	5068.313	3.228	14.269	903.231
468.000	5054.053	3.219	14.261	903.231
469.000	5039.800	3.210	14.252	903.231
470.000	5025.557	3.201	14.244	903.231
471.000	5011.321	3.192	14.235	903.231
472.000	4997.094	3.183	14.227	903.231
473.000	4982.876	3.174	14.219	903.231
474.000	4968.666	3.165	14.210	903.231
475.000	4954.464	3.156	14.202	903.231

476.000	4940.270	3.147	14.194	903.231
477.000	4926.085	3.138	14.185	903.231
478.000	4911.908	3.129	14.177	903.231
479.000	4897.739	3.120	14.169	903.231
480.000	4883.578	3.111	14.161	903.231
481.000	4869.426	3.102	14.153	903.231
482.000	4855.281	3.093	14.144	903.231
483.000	4841.145	3.084	14.136	903.231
484.000	4827.017	3.075	14.128	903.231
485.000	4812.897	3.066	14.120	903.231
486.000	4798.785	3.057	14.112	903.231
487.000	4784.681	3.048	14.104	903.231
488.000	4770.585	3.039	14.096	903.231
489.000	4756.497	3.030	14.088	903.231
490.000	4742.417	3.021	14.080	903.231
491.000	4728.344	3.012	14.072	903.231
492.000	4714.280	3.003	14.064	903.231
493.000	4700.223	2.994	14.056	903.231
494.000	4686.175	2.985	14.049	903.231
495.000	4672.134	2.976	14.041	903.231
496.000	4658.101	2.967	14.033	903.231
497.000	4644.076	2.958	14.025	903.231
498.000	4630.058	2.949	14.017	903.231
499.000	4616.048	2.940	14.010	903.231
500.000	4602.046	2.931	14.002	903.231
501.000	4588.052	2.922	13.994	903.231
502.000	4574.065	2.913	13.987	903.231
503.000	4560.086	2.905	13.979	903.231
504.000	4546.115	2.896	13.971	903.231
505.000	4532.151	2.887	13.964	903.231
506.000	4518.194	2.878	13.956	903.231
507.000	4504.246	2.869	13.949	903.231
508.000	4490.304	2.860	13.941	903.231
509.000	4476.371	2.851	13.934	903.231
510.000	4462.444	2.842	13.926	903.231
511.000	4448.526	2.833	13.919	903.231
512.000	4434.614	2.825	13.911	903.231
513.000	4420.710	2.816	13.904	903.231
514.000	4406.814	2.807	13.897	903.231
515.000	4392.924	2.798	13.889	903.231
516.000	4379.042	2.789	13.882	903.231
517.000	4365.168	2.780	13.875	903.231
518.000	4351.301	2.772	13.867	903.231
519.000	4337.441	2.763	13.860	903.231
520.000	4323.588	2.754	13.853	903.231
521.000	4309.742	2.745	13.845	903.231
522.000	4295.904	2.736	13.838	903.231
523.000	4282.073	2.727	13.831	903.231
524.000	4268.249	2.719	13.824	903.231
525.000	4254.433	2.710	13.817	903.231
526.000	4240.623	2.701	13.810	903.231
527.000	4226.821	2.692	13.802	903.231
528.000	4213.025	2.683	13.795	903.231

529.000	4199.237	2.675	13.788	903.231
530.000	4185.456	2.666	13.781	903.231

Output file is validatn.evp

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0.000	1.254	0.000
1.000	7.838	0.000
2.000	10.345	0.000
3.000	12.435	0.000
4.000	14.269	0.000
5.000	15.928	0.000
6.000	17.457	0.000
7.000	18.886	0.000
8.000	20.232	0.000
9.000	21.511	0.000
10.000	22.731	0.000
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Calculation No. SL-9929-M-0008  
Revision 0  
Project No. 09929-036  
Attachment E  
Page No. E31

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CALCULATION No. SL-9929-M-000  
REVISION 1  
PROJECT No. 09929-036  
ATTACHMENT E PAGE E32  
FINAL PAGE



# Wind Tunnel Testing to Determine SO<sub>2</sub> Concentrations at the Control Room Intake for Florida Power Corporation's Crystal River Unit #3

CPP Report 97-1526.RO

Prepared for:

Sargent & Lundy  
55 East Monroe St.  
Chicago, Ill 60603

Prepared by:



Ronald L. Petersen, Ph.D., CCM  
Project Manager

Quality Assurance Review by:

\_\_\_\_\_  
Jack E. Cermak, Ph.D.  
President

Cermak Peterka Petersen, Inc.  
*Wind Engineering Consultants*  
1415 Blue Spruce Drive  
Fort Collins, Colorado 80524

November 1997

## Instantaneous Release

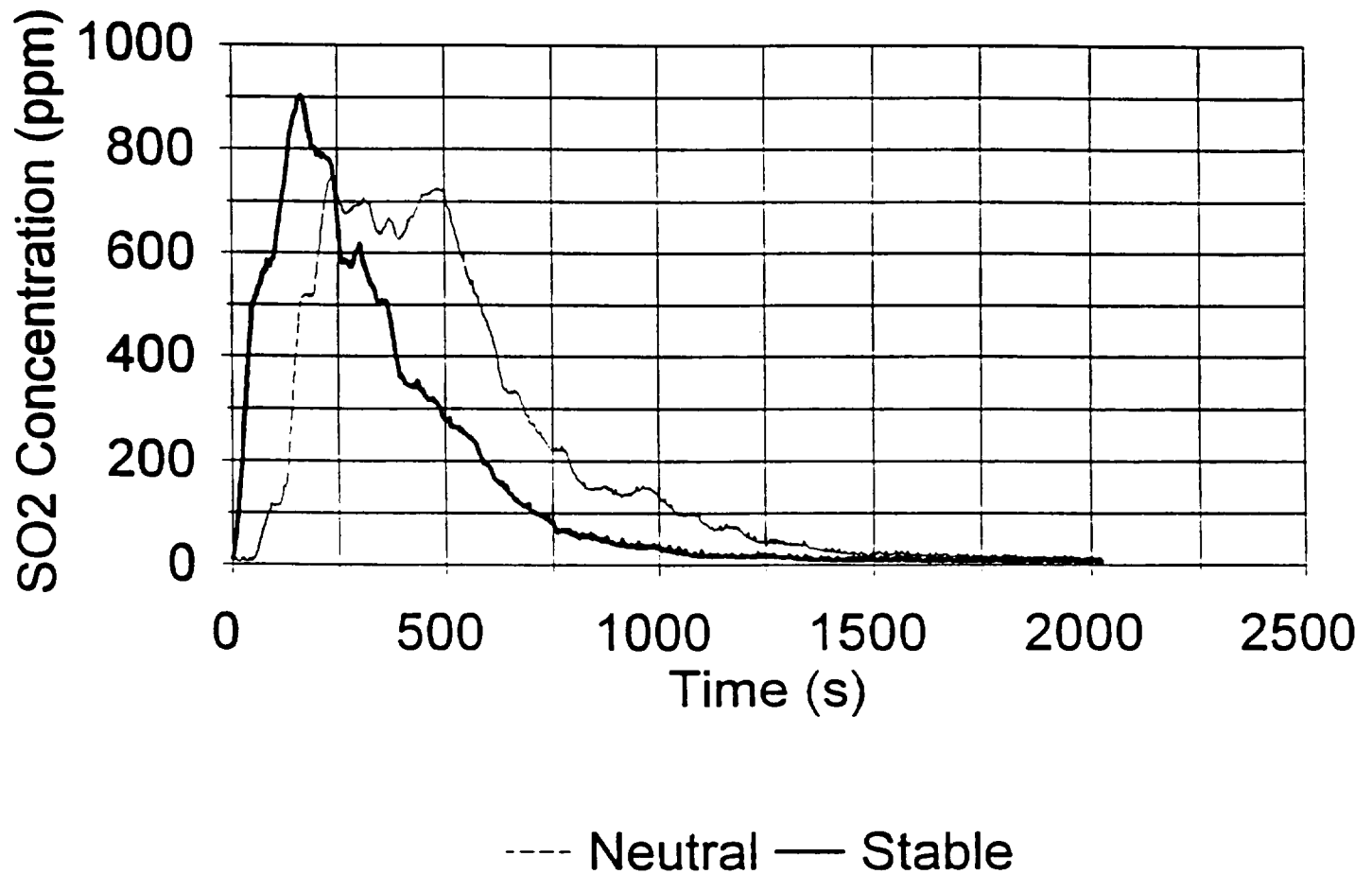


Figure 13. Maximum SO<sub>2</sub> concentration versus time for the instantaneous portion of the 30 ton tank release-neutral and stable stratification

## Evaporating Pool Release

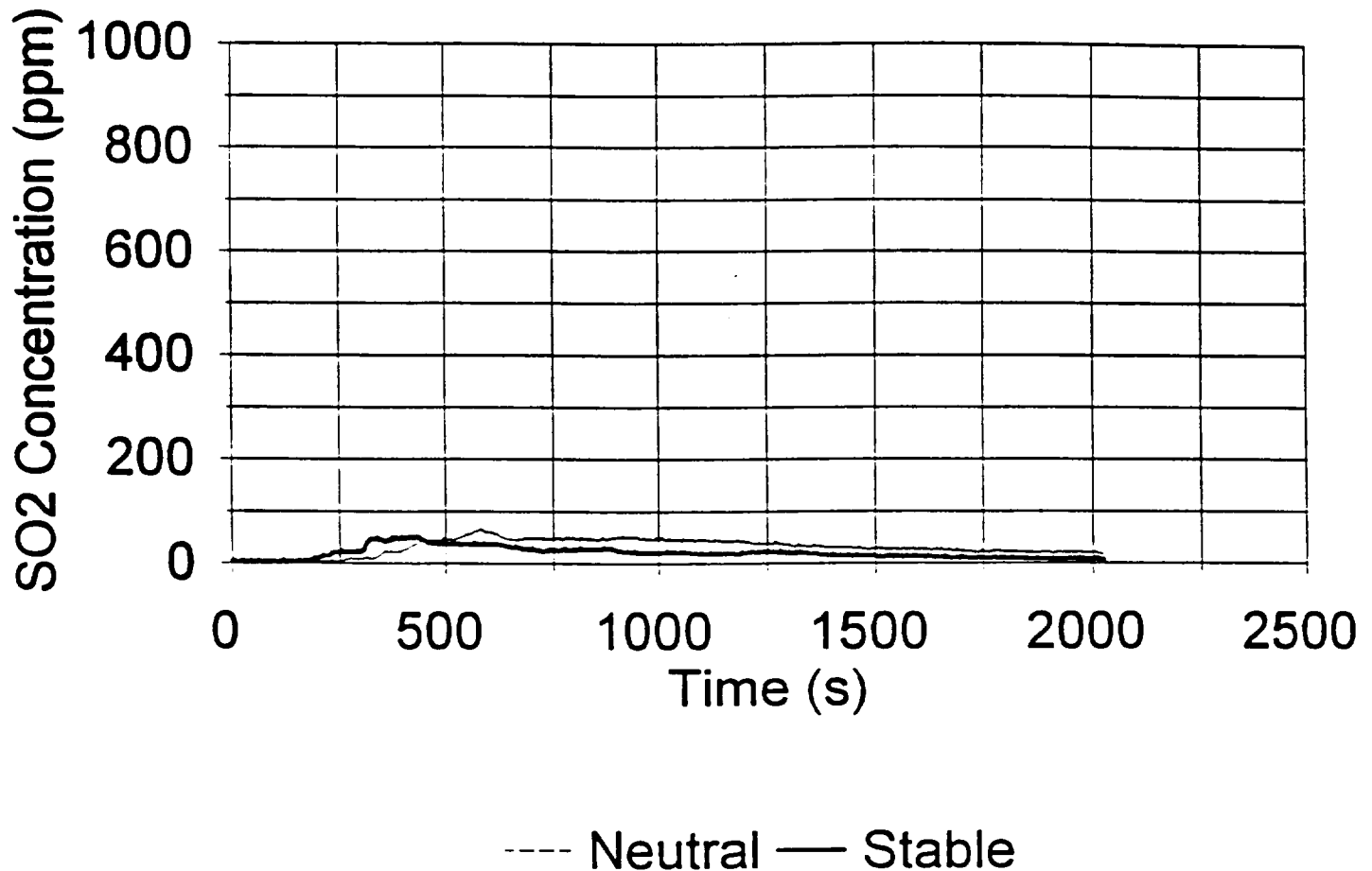


Figure 14. Maximum SO<sub>2</sub> concentration versus time for the evaporating pool portion of the 30 ton tank release-neutral and stable stratification

**Table 6**  
**SO2 Concentration (ppm) Versus Time**  
**Maximum at Each Time Based on 7 Repetitions**

Time (s)	Run 302 Evap Neutral	Run 303 Instan Neutral	Run 401 Evap Stable	Run 402 Instan Stable
0.0	3	13	4	10
2.8	2	12	2	17
5.7	3	6	5	22
8.5	3	12	4	43
11.3	2	9	2	61
14.2	2	4	1	87
17.0	2	5	2	111
19.8	4	4	2	143
22.7	2	12	4	175
25.5	3	9	3	210
28.3	3	13	5	248
31.2	3	6	1	281
34.0	5	6	2	319
36.8	4	5	1	354
39.7	3	8	3	392
42.5	4	12	2	425
45.3	3	6	4	459
48.2	3	7	1	490
51.0	3	13	2	502
53.8	2	13	2	511
56.7	4	19	1	515
59.5	4	24	3	517
62.3	3	29	4	528
65.2	3	39	5	534
68.0	3	50	2	539
70.8	3	58	1	546
73.7	3	67	2	556
76.5	6	74	3	566
79.3	6	83	1	563
82.2	2	89	4	569
85.0	4	97	3	586
87.8	5	104	2	580
90.7	2	107	1	575
93.5	6	118	2	581
96.3	2	116	4	588
99.2	3	115	3	590
102.0	2	112	4	599
104.8	3	117	2	609
107.7	5	115	1	642
110.5	2	116	2	646
113.3	2	115	3	665
116.2	2	122	1	682
119.0	2	134	4	702
121.8	4	152	7	719
124.7	2	149	3	724
127.5	2	153	1	743

**Table 6**  
**SO2 Concentration (ppm) Versus Time**  
**Maximum at Each Time Based on 7 Repetitions**

Calculation No. SL-9929-M-0008  
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 Attachment F  
 Page No. F5

Time (s)	Run 302 Evap Neutral	Run 303 Instan Neutral	Run 401 Evap Stable	Run 402 Instan Stable
130.3	5	162	2	762
133.2	2	187	5	781
136.0	3	220	3	800
138.8	4	249	3	819
141.7	2	286	4	838
144.5	2	319	3	848
147.3	2	354	3	856
150.2	2	389	2	864
153.0	2	416	3	872
155.8	2	447	5	878
158.7	2	467	7	894
161.5	2	492	2	897
164.3	2	512	3	903
167.2	5	517	3	903
170.0	2	514	5	897
172.8	4	523	5	885
175.7	4	519	4	882
178.5	2	520	5	866
181.3	5	521	6	851
184.2	2	514	6	836
187.0	3	521	7	829
189.8	2	515	7	816
192.7	2	521	12	802
195.5	2	522	11	801
198.3	2	551	9	804
201.2	2	567	9	796
204.0	2	588	12	789
206.8	3	605	12	792
209.7	3	622	12	796
212.5	3	642	17	790
215.3	2	660	16	784
218.2	4	681	15	792
221.0	3	700	14	787
223.8	5	709	14	786
226.7	2	726	15	781
229.5	2	737	18	782
232.3	6	738	21	782
235.2	3	746	19	776
238.0	3	741	21	768
240.8	2	745	23	753
243.7	3	733	23	743
246.5	2	737	22	713
249.3	4	721	22	680
252.2	5	713	24	653
255.0	4	705	26	620
257.8	4	693	23	598

**Table 6**  
**SO2 Concentration (ppm) Versus Time**  
**Maximum at Each Time Based on 7 Repetitions**

Time (s)	Run 302 Evap Neutral	Run 303 Instan Neutral	Run 401 Evap Stable	Run 402 Instan Stable
260.7	5	694	22	581
263.5	6	679	22	584
266.3	7	682	23	582
269.2	7	675	22	588
272.0	8	676	22	582
274.8	11	679	22	584
277.7	9	678	23	581
280.5	9	685	21	573
283.3	9	682	21	575
286.2	9	689	22	580
289.0	9	689	23	587
291.8	8	691	25	603
294.7	8	693	21	602
297.5	9	691	23	603
300.3	10	695	22	609
303.2	9	691	26	618
306.0	9	700	25	604
308.8	10	695	30	592
311.7	11	709	35	580
314.5	13	700	40	575
317.3	9	701	43	566
320.2	11	700	43	558
323.0	9	695	47	556
325.8	9	699	47	546
328.7	9	681	48	539
331.5	10	681	47	540
334.3	11	667	47	537
337.2	12	657	48	528
340.0	13	652	50	522
342.8	15	642	46	509
345.7	16	643	46	502
348.5	18	635	46	502
351.3	20	642	45	503
354.2	20	636	43	510
357.0	25	650	42	509
359.8	22	647	42	507
362.7	23	650	43	509
365.5	22	659	43	507
368.3	23	663	44	497
371.2	23	669	45	487
374.0	22	666	49	474
376.8	23	663	52	469
379.7	22	660	47	441
382.5	23	652	50	428
385.3	22	648	50	416
388.2	21	636	49	400

Table G1  
Spreadsheet Formulas for Table 5

	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2													
3													
4													
5													
6	T	P <sub>sat</sub>	h <sub>f</sub>	h <sub>g</sub>	h <sub>fg</sub>	v <sub>f</sub>	v <sub>g</sub>	v <sub>fg</sub>	α	β	dβ/dP	dα/dP	G <sub>s</sub>
7	(°F)	(psia)	(Btu/lb)	(Btu/lb)	(Btu/lb)	(ft <sup>3</sup> /lb)	(ft <sup>3</sup> /lb)	(ft <sup>3</sup> /lb)	(Btu/ft <sup>3</sup> )	(Btu/lb)	(Btu/lb-psia)	(Btu/ft <sup>3</sup> -psia)	(lb/ft <sup>2</sup> -sec)
8													
9	10	13.3	35.7	204	=D9-C9	0.01092	5.77	=G9-F9	=E9/H9	=C9-I9*F9			
10	20	16.9	39	205.3	=D10-C10	0.01103	4.59	=G10-F10	=E10/H10	=C10-I10*F10	=(J10-J9)/(B10-B9)	=(I10-I9)/(B10-B9)	=SQRT((144*I10*32.2)/(K10+F10*(L10-144/778.16)))
11	30	21.3	42.2	206.4	=D11-C11	0.01114	3.7	=G11-F11	=E11/H11	=C11-I11*F11	=(J11-J10)/(B11-B10)	=(I11-I10)/(B11-B10)	=SQRT((144*I11*32.2)/(K11+F11*(L11-144/778.16)))
12	40	26.6	45.5	207.7	=D12-C12	0.01125	3.02	=G12-F12	=E12/H12	=C12-I12*F12	=(J12-J11)/(B12-B11)	=(I12-I11)/(B12-B11)	=SQRT((144*I12*32.2)/(K12+F12*(L12-144/778.16)))
13	50	32.9	48.7	208.7	=D13-C13	0.01137	2.48	=G13-F13	=E13/H13	=C13-I13*F13	=(J13-J12)/(B13-B12)	=(I13-I12)/(B13-B12)	=SQRT((144*I13*32.2)/(K13+F13*(L13-144/778.16)))
14	60	40.3	52	209.8	=D14-C14	0.01149	2.05	=G14-F14	=E14/H14	=C14-I14*F14	=(J14-J13)/(B14-B13)	=(I14-I13)/(B14-B13)	=SQRT((144*I14*32.2)/(K14+F14*(L14-144/778.16)))
15	70	49.1	55.3	210.8	=D15-C15	0.01162	1.7	=G15-F15	=E15/H15	=C15-I15*F15	=(J15-J14)/(B15-B14)	=(I15-I14)/(B15-B14)	=SQRT((144*I15*32.2)/(K15+F15*(L15-144/778.16)))
16	80	59.3	58.6	211.7	=D16-C16	0.01175	1.42	=G16-F16	=E16/H16	=C16-I16*F16	=(J16-J15)/(B16-B15)	=(I16-I15)/(B16-B15)	=SQRT((144*I16*32.2)/(K16+F16*(L16-144/778.16)))
17	90	71	61.9	212.6	=D17-C17	0.01189	1.2	=G17-F17	=E17/H17	=C17-I17*F17	=(J17-J16)/(B17-B16)	=(I17-I16)/(B17-B16)	=SQRT((144*I17*32.2)/(K17+F17*(L17-144/778.16)))
18	100	84.1	65.3	213.5	=D18-C18	0.01204	1.02	=G18-F18	=E18/H18	=C18-I18*F18	=(J18-J17)/(B18-B17)	=(I18-I17)/(B18-B17)	=SQRT((144*I18*32.2)/(K18+F18*(L18-144/778.16)))
19	110	99.1	68.8	214.5	=D19-C19	0.01219	0.868	=G19-F19	=E19/H19	=C19-I19*F19	=(J19-J18)/(B19-B18)	=(I19-I18)/(B19-B18)	=SQRT((144*I19*32.2)/(K19+F19*(L19-144/778.16)))
20	120	116.3	72.2	215.2	=D20-C20	0.01235	0.746	=G20-F20	=E20/H20	=C20-I20*F20	=(J20-J19)/(B20-B19)	=(I20-I19)/(B20-B19)	=SQRT((144*I20*32.2)/(K20+F20*(L20-144/778.16)))
21	130	135.8	75.8	215.8	=D21-C21	0.01251	0.646	=G21-F21	=E21/H21	=C21-I21*F21	=(J21-J20)/(B21-B20)	=(I21-I20)/(B21-B20)	=SQRT((144*I21*32.2)/(K21+F21*(L21-144/778.16)))
22	140	157.7	79.3	216.4	=D22-C22	0.01269	0.554	=G22-F22	=E22/H22	=C22-I22*F22	=(J22-J21)/(B22-B21)	=(I22-I21)/(B22-B21)	=SQRT((144*I22*32.2)/(K22+F22*(L22-144/778.16)))

**Table G2**  
**Spreadsheet Formulas for Table 6**

	A	B	C	D	E
1					
2					
3	Control Complex Volume		364922		
4	Ventilation Rate (cfm)		5700		
5	Nasal Detection Concentr		3		
6					
7					
8				Total Intake Concentration	Control Complex Concentration
9	time	Puff Concentration	Plume Concentration	Co	Cr
10	(sec)	(ppm)	(ppm)	(ppm)	(ppm)
11					
12	0	10	4	=B12+C12	0
13	2.8	17	2	=B13+C13	=E12+(D13-E12)*(1-EXP(-SC\$4/60*(A13-A12)/SC\$3))
14	5.7	22	5	=B14+C14	=E13+(D14-E13)*(1-EXP(-SC\$4/60*(A14-A13)/SC\$3))
15	8.5	43	4	=B15+C15	=E14+(D15-E14)*(1-EXP(-SC\$4/60*(A15-A14)/SC\$3))
16	11.3	61	2	=B16+C16	=E15+(D16-E15)*(1-EXP(-SC\$4/60*(A16-A15)/SC\$3))
17	14.2	87	1	=B17+C17	=E16+(D17-E16)*(1-EXP(-SC\$4/60*(A17-A16)/SC\$3))
18	17	111	2	=B18+C18	=E17+(D18-E17)*(1-EXP(-SC\$4/60*(A18-A17)/SC\$3))
19	19.8	143	2	=B19+C19	=E18+(D19-E18)*(1-EXP(-SC\$4/60*(A19-A18)/SC\$3))
20	22.7	175	4	=B20+C20	=E19+(D20-E19)*(1-EXP(-SC\$4/60*(A20-A19)/SC\$3))
21	25.5	210	3	=B21+C21	=E20+(D21-E20)*(1-EXP(-SC\$4/60*(A21-A20)/SC\$3))
22	28.3	246	5	=B22+C22	=E21+(D22-E21)*(1-EXP(-SC\$4/60*(A22-A21)/SC\$3))
23	31.2	281	1	=B23+C23	=E22+(D23-E22)*(1-EXP(-SC\$4/60*(A23-A22)/SC\$3))
24	34	319	2	=B24+C24	=E23+(D24-E23)*(1-EXP(-SC\$4/60*(A24-A23)/SC\$3))
25	36.8	354	1	=B25+C25	=E24+(D25-E24)*(1-EXP(-SC\$4/60*(A25-A24)/SC\$3))
26	39.7	392	3	=B26+C26	=E25+(D26-E25)*(1-EXP(-SC\$4/60*(A26-A25)/SC\$3))
27	42.5	425	2	=B27+C27	=E26+(D27-E26)*(1-EXP(-SC\$4/60*(A27-A26)/SC\$3))
28	45.3	459	4	=B28+C28	=E27+(D28-E27)*(1-EXP(-SC\$4/60*(A28-A27)/SC\$3))
29	48.2	490	1	=B29+C29	=E28+(D29-E28)*(1-EXP(-SC\$4/60*(A29-A28)/SC\$3))
30	51	502	2	=B30+C30	=E29+(D30-E29)*(1-EXP(-SC\$4/60*(A30-A29)/SC\$3))
31	53.8	511	2	=B31+C31	=E30+(D31-E30)*(1-EXP(-SC\$4/60*(A31-A30)/SC\$3))
32	56.7	515	1	=B32+C32	=E31+(D32-E31)*(1-EXP(-SC\$4/60*(A32-A31)/SC\$3))
33	59.5	517	3	=B33+C33	=E32+(D33-E32)*(1-EXP(-SC\$4/60*(A33-A32)/SC\$3))
34	62.3	528	4	=B34+C34	=E33+(D34-E33)*(1-EXP(-SC\$4/60*(A34-A33)/SC\$3))
35	65.2	534	5	=B35+C35	=E34+(D35-E34)*(1-EXP(-SC\$4/60*(A35-A34)/SC\$3))
36	68	539	2	=B36+C36	=E35+(D36-E35)*(1-EXP(-SC\$4/60*(A36-A35)/SC\$3))
37	70.8	546	1	=B37+C37	=E36+(D37-E36)*(1-EXP(-SC\$4/60*(A37-A36)/SC\$3))
38	73.7	556	2	=B38+C38	=E37+(D38-E37)*(1-EXP(-SC\$4/60*(A38-A37)/SC\$3))
39	76.5	566	3	=B39+C39	=E38+(D39-E38)*(1-EXP(-SC\$4/60*(A39-A38)/SC\$3))
40	79.3	563	1	=B40+C40	=E39+(D40-E39)*(1-EXP(-SC\$4/60*(A40-A39)/SC\$3))
41	82.2	569	4	=B41+C41	=E40+(D41-E40)*(1-EXP(-SC\$4/60*(A41-A40)/SC\$3))
42	85	586	3	=B42+C42	=E41+(D42-E41)*(1-EXP(-SC\$4/60*(A42-A41)/SC\$3))
43	87.8	580	2	=B43+C43	=E42+(D43-E42)*(1-EXP(-SC\$4/60*(A43-A42)/SC\$3))
44	90.7	575	1	=B44+C44	=E43+(D44-E43)*(1-EXP(-SC\$4/60*(A44-A43)/SC\$3))
45	93.5	581	2	=B45+C45	=E44+(D45-E44)*(1-EXP(-SC\$4/60*(A45-A44)/SC\$3))
46	96.3	588	4	=B46+C46	=E45+(D46-E45)*(1-EXP(-SC\$4/60*(A46-A45)/SC\$3))
47	99.2	590	3	=B47+C47	=E46+(D47-E46)*(1-EXP(-SC\$4/60*(A47-A46)/SC\$3))
48	102	599	4	=B48+C48	=E47+(D48-E47)*(1-EXP(-SC\$4/60*(A48-A47)/SC\$3))
49	104.8	609	2	=B49+C49	=E48+(D49-E48)*(1-EXP(-SC\$4/60*(A49-A48)/SC\$3))
50	107.7	642	1	=B50+C50	=E49+(D50-E49)*(1-EXP(-SC\$4/60*(A50-A49)/SC\$3))
51	110.5	646	2	=B51+C51	=E50+(D51-E50)*(1-EXP(-SC\$4/60*(A51-A50)/SC\$3))
52	113.3	665	3	=B52+C52	=E51+(D52-E51)*(1-EXP(-SC\$4/60*(A52-A51)/SC\$3))
53	116.2	682	1	=B53+C53	=E52+(D53-E52)*(1-EXP(-SC\$4/60*(A53-A52)/SC\$3))
54	119	702	4	=B54+C54	=E53+(D54-E53)*(1-EXP(-SC\$4/60*(A54-A53)/SC\$3))




**Table G2**  
**Spreadsheet Formulas for Table 6**

*FINAL PAGE*

	A	B	C	D	E
55	121.8	719	7	=B55+C55	=E54+(D55-E54)*(1-EXP(-SC\$4/60*(A55-A54)/SC\$3))
56	124.7	724	3	=B56+C56	=E55+(D56-E55)*(1-EXP(-SC\$4/60*(A56-A55)/SC\$3))
57	127.5	743	1	=B57+C57	=E56+(D57-E56)*(1-EXP(-SC\$4/60*(A57-A56)/SC\$3))
58	130.3	762	2	=B58+C58	=E57+(D58-E57)*(1-EXP(-SC\$4/60*(A58-A57)/SC\$3))
59	133.2	781	5	=B59+C59	=E58+(D59-E58)*(1-EXP(-SC\$4/60*(A59-A58)/SC\$3))
60	136	800	3	=B60+C60	=E59+(D60-E59)*(1-EXP(-SC\$4/60*(A60-A59)/SC\$3))
61	138.8	819	3	=B61+C61	=E60+(D61-E60)*(1-EXP(-SC\$4/60*(A61-A60)/SC\$3))
62	141.7	838	4	=B62+C62	=E61+(D62-E61)*(1-EXP(-SC\$4/60*(A62-A61)/SC\$3))
63	144.5	848	3	=B63+C63	=E62+(D63-E62)*(1-EXP(-SC\$4/60*(A63-A62)/SC\$3))
64	147.3	856	3	=B64+C64	=E63+(D64-E63)*(1-EXP(-SC\$4/60*(A64-A63)/SC\$3))
65	150.2	864	2	=B65+C65	=E64+(D65-E64)*(1-EXP(-SC\$4/60*(A65-A64)/SC\$3))
66	153	872	3	=B66+C66	=E65+(D66-E65)*(1-EXP(-SC\$4/60*(A66-A65)/SC\$3))
67	155.8	878	5	=B67+C67	=E66+(D67-E66)*(1-EXP(-SC\$4/60*(A67-A66)/SC\$3))
68	158.7	894	7	=B68+C68	=E67+(D68-E67)*(1-EXP(-SC\$4/60*(A68-A67)/SC\$3))
69	161.5	897	2	=B69+C69	=E68+(D69-E68)*(1-EXP(-SC\$4/60*(A69-A68)/SC\$3))
70	164.3	903	3	=B70+C70	=E69+(D70-E69)*(1-EXP(-SC\$4/60*(A70-A69)/SC\$3))
71	167.2	903	3	=B71+C71	=E70+(D71-E70)*(1-EXP(-SC\$4/60*(A71-A70)/SC\$3))
72	170	897	5	=B72+C72	=E71+(D72-E71)*(1-EXP(-SC\$4/60*(A72-A71)/SC\$3))
73	172.8	885	5	=B73+C73	=E72+(D73-E72)*(1-EXP(-SC\$4/60*(A73-A72)/SC\$3))
74	175.7	882	4	=B74+C74	=E73+(D74-E73)*(1-EXP(-SC\$4/60*(A74-A73)/SC\$3))
75	178.5	866	5	=B75+C75	=E74+(D75-E74)*(1-EXP(-SC\$4/60*(A75-A74)/SC\$3))
76	181.3	851	6	=B76+C76	=E75+(D76-E75)*(1-EXP(-SC\$4/60*(A76-A75)/SC\$3))
77	184.2	836	6	=B77+C77	=E76+(D77-E76)*(1-EXP(-SC\$4/60*(A77-A76)/SC\$3))
78	187	829	7	=B78+C78	=E77+(D78-E77)*(1-EXP(-SC\$4/60*(A78-A77)/SC\$3))
79	189.8	816	7	=B79+C79	=E78+(D79-E78)*(1-EXP(-SC\$4/60*(A79-A78)/SC\$3))
80	192.7	802	12	=B80+C80	=E79+(D80-E79)*(1-EXP(-SC\$4/60*(A80-A79)/SC\$3))
81	195.5	801	11	=B81+C81	=E80+(D81-E80)*(1-EXP(-SC\$4/60*(A81-A80)/SC\$3))
82	198.3	804	9	=B82+C82	=E81+(D82-E81)*(1-EXP(-SC\$4/60*(A82-A81)/SC\$3))
83	201.2	796	9	=B83+C83	=E82+(D83-E82)*(1-EXP(-SC\$4/60*(A83-A82)/SC\$3))
84	204	789	12	=B84+C84	=E83+(D84-E83)*(1-EXP(-SC\$4/60*(A84-A83)/SC\$3))
85	206.8	792	12	=B85+C85	=E84+(D85-E84)*(1-EXP(-SC\$4/60*(A85-A84)/SC\$3))
86	209.7	796	12	=B86+C86	=E85+(D86-E85)*(1-EXP(-SC\$4/60*(A86-A85)/SC\$3))
87	212.5	790	17	=B87+C87	=E86+(D87-E86)*(1-EXP(-SC\$4/60*(A87-A86)/SC\$3))
88	215.3	784	16	=B88+C88	=E87+(D88-E87)*(1-EXP(-SC\$4/60*(A88-A87)/SC\$3))
89	218.2	792	15	=B89+C89	=E88+(D89-E88)*(1-EXP(-SC\$4/60*(A89-A88)/SC\$3))
90	221	787	14	=B90+C90	=E89+(D90-E89)*(1-EXP(-SC\$4/60*(A90-A89)/SC\$3))
91	223.8	786	14	=B91+C91	=E90+(D91-E90)*(1-EXP(-SC\$4/60*(A91-A90)/SC\$3))
92	226.7	781	15	=B92+C92	=E91+(D92-E91)*(1-EXP(-SC\$4/60*(A92-A91)/SC\$3))
93	229.5	782	18	=B93+C93	=E92+(D93-E92)*(1-EXP(-SC\$4/60*(A93-A92)/SC\$3))
94	232.3	782	21	=B94+C94	=E93+(D94-E93)*(1-EXP(-SC\$4/60*(A94-A93)/SC\$3))
95	235.2	776	19	=B95+C95	=E94+(D95-E94)*(1-EXP(-SC\$4/60*(A95-A94)/SC\$3))
96	238	768	21	=B96+C96	=E95+(D96-E95)*(1-EXP(-SC\$4/60*(A96-A95)/SC\$3))
97	240.8	753	23	=B97+C97	=E96+(D97-E96)*(1-EXP(-SC\$4/60*(A97-A96)/SC\$3))
98	243.7	743	23	=B98+C98	=E97+(D98-E97)*(1-EXP(-SC\$4/60*(A98-A97)/SC\$3))
99	246.5	713	22	=B99+C99	=E98+(D99-E98)*(1-EXP(-SC\$4/60*(A99-A98)/SC\$3))
100	249.3	680	22	=B100+C100	=E99+(D100-E99)*(1-EXP(-SC\$4/60*(A100-A99)/SC\$3))
101	252.2	653	24	=B101+C101	=E100+(D101-E100)*(1-EXP(-SC\$4/60*(A101-A100)/SC\$3))
102	255	620	26	=B102+C102	=E101+(D102-E101)*(1-EXP(-SC\$4/60*(A102-A101)/SC\$3))
103	257.8	598	23	=B103+C103	=E102+(D103-E102)*(1-EXP(-SC\$4/60*(A103-A102)/SC\$3))

## Design Information Transmittal

<input checked="" type="checkbox"/> SAFETY-RELATED	<input type="checkbox"/> NON-SAFETY-RELATED	DIT No. <u>DIT-CR-0044</u>
Client: <u>Florida Power Corporation</u>		Page <u>1</u> of <u>1</u>
Station: <u>Crystal River</u> Unit(s) <u>3</u>		To: <u>Walter De Lise</u>
Project No(s): <u>09929-036</u>		
Subject: <u>Control Complex Volume</u>		
<b>MODIFICATION OR DESIGN CHANGE NUMBER(S):</b>		
<u>James Mierke</u> <small>Preparer (Please print name)</small>	<u>HVAC</u> <small>Division</small>	 <small>Preparer's Signature</small>
		<u>10/1/1997</u> <small>Date</small>
<b>STATUS OF INFORMATION:</b> (This information is approved for use. Design information, approved for use, that contains assumptions or is preliminary or requires further verification (review) shall be so identified.)  The information in this DIT is approved for use. No further verification is required.		
<b>IDENTIFICATION OF THE SPECIFIC DESIGN INFORMATION TRANSMITTED AND PURPOSE OF ISSUE</b> (List any supporting documents attached to DIT by its title, revision and/or issue date, and total number of pages for each supporting document)		
The purpose of this DIT is to transmit the calculated air flow rate for emergency filter unit fans (AHF-18A/-18B), the calculated total volume of the control complex (excluding the 95' elev.), and the calculated volume of the HVAC equipment room at the 164' elev.		
Control Complex total volume      364,922 cubic feet per SL-9929-M-006		
HVAC equipment room volume      83,663 cubic feet per SL-9929-M-006		
Air flow rate of AHF-18A/-18B      37,800 cubic feet per minute (cfm) per SL-9929-M-007		
<b>SOURCE OF INFORMATION:</b>		
Calc. No. <u>SL-9929-M-006</u>	Rev. 0, 10/1/1997	Report No.
<u>SL-9929-M-007</u>	Rev. 0, 10/1/1997	
	<small>Rev. and/or date</small>	<small>Rev. and/or date</small>
Other		
Distribution: <u>Mark Handrick, Ravi Aggarwal</u>		
<u>24W 28</u>		
File No.: <u>2.2</u>		

Calculation No. SL-9929-M-0008  
PROJECT No. 09929-036 Revision 1  
Attachment H  
Page No. H1

## Design Information Transmittal

<input checked="" type="checkbox"/> SAFETY-RELATED		<input type="checkbox"/> NON-SAFETY-RELATED		DIT No. <u>DIT-CR-0054-1</u>	
Client: <u>Florida Power Corporation</u>				Page 1 of 1	
Station: <u>Crystal River</u>		Unit(s) <u>3</u>		To: <u>C.F. Mevers</u>	
Project No(s): <u>09929-036</u>					
Subject: <u>Maximum unfiltered leakage</u>					
<b>MODIFICATION OR DESIGN CHANGE NUMBER(S):</b>					
<u>W.E. De Lise</u> Preparer (Please print name)		<u>NTRD</u> Division		<u>W.E. De Lise</u> Preparer's Signature	
				<u>11/25/97</u> Date	
<b>STATUS OF INFORMATION:</b> (This information is approved for use. Design information, approved for use, that contains assumptions or is preliminary or requires further verification (review) shall be so identified.)					
<u>Verified</u>					
<b>IDENTIFICATION OF THE SPECIFIC DESIGN INFORMATION TRANSMITTED AND PURPOSE OF ISSUE</b> (List any supporting documents attached to DIT by its title, revision and/or issue date, and total number of pages for each supporting document)					
<p>The purpose of this DIT is to transmit the Maximum Expected Calculated Unfiltered Leakage for the Crystal River unit #3 Control Complex. The information source has <u>these</u> leakage rates occurring during the 96-720 hour post LOCA time period. <u>These</u> leakage rates <u>are</u> the most conservative values that can be used <u>for non-radiological incidents and in the evaluation of the Fuel Handling Accident</u>.</p> <p><u>The maximum expected leakage rate for non-radiological incidents is 284 cfm (which includes 10 cfm egress leakage) of unfiltered leakage plus 125 cfm (see next paragraph) of potentially filtered leakage. Thus, the total leakage is 409 cfm. The previously specified maximum unfiltered leakage of 435 cfm is conservative and can still be applied to non-radiological incidents. These leakages apply to the Control Complex total volume that was transmitted to NTRD in DIT-CR-0044, i.e., 364,922 cubic feet.</u></p> <p><u>The updated information source has determined a new unfiltered leakage rate and added Assumption 3.26 which incorporates a new leakage pathway that is induced by HVAC duct leakage on the equipment floor. These two leakage values should be applied to the FHA. The first one is 379 cfm of unfiltered leakage that applies to the entire post accident recovery period. The second one is 125 cfm of leakage that is unfiltered for the first 30 minute and filtered after that time. Thus, during the first 30 minutes there will be 504 cfm of unfiltered leakage.</u></p>					
<b>SOURCE OF INFORMATION:</b>					
Calc. No. <u>SL-9929-M-009</u>		<u>1 / 11-25-97</u> Rev. and/or date		Report No. _____ Rev. and/or date _____	
Other <u>The underlined text indicates the added and revised design information.</u>					
Distribution: <u>R. Aggarwal; B.J. Andrews; M.C. Handrick; W.J. Johnson; H.S. Taylor</u>					
File No.: <u>6.2</u>					

Calculation No. SL-9929-M-0008  
 PROJECT No. 09929-036 Revision 1  
 Attachment H  
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 FINAL PAGE