U-0694
0210.6-L
L30-84(02-08)-L

ILLINOIS POWER COMPANY

CLINTON POWER STATION, P.O. BOX 678, CLINTON, ILLINOIS 61727

February 8, 1984

Docket No. 50-461

Director of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Clinton Power Station Unit 1
SER Outstanding Issue #1 (NUREG-0853)
Transportation Accidents

Dear Mr. Schwencer:

Illinois Power Company letter U-0693 dated January 31, 1984 was intended to provide the presentation material used at the September 23, 1983 meeting on the subject issue. We understand this issue will be resolved in Supplement No. 3 to the Clinton Safety Evaluation Report. Due to an administrative error the attachment was not included in the mailing of the aforementioned letter. This letter provides the material which was inadvertently omitted together with a copy of IP letter U-0693. Illinois Power Company regrets the administrative error and hopes that it does not seriously inconvenience the handling of the issue closure.

Sincerely yours,

J. D. Geier
Manager
Nuclear Station Engineering

GEW/lam

Attachment

cc: G. A. Harrison, NRC Clinton Licensing Project Manager
NRC Resident Office
Illinois Department of Nuclear Safety

B001
1/1

ILLINOIS POWER COMPANY

U-0693
0210.6-L-
L30-84(01-31)L
500 SOUTH 27TH STREET, DECATUR, ILLINOIS 62525

January 31, 1984

Docket No. 50-461

Director of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Clinton Power Station Unit 1
SER Outstanding Issue # 1 (NUREG-0853)
Transportation Accidents

Dear Mr. Schwencer:

A meeting was held at the NRC offices in Bethesda, Maryland on September 23, 1983 to discuss the subject issue. The NRC meeting summary is given in Mr. G. Harrison's memorandum of December 20, 1983 wherein he requested formal documenting of the Illinois Power Company (IP) findings and analysis on the transportation accident issue.

Attached to close this issue are the IP presentation materials used at the September 23 meeting. We understand this issue will be resolved in Supplement No. 3 to the Clinton Safety Evaluation Report.

Sincerely yours,

J. D. Geier
Manager
Nuclear Station Engineering

[redacted]/jmm Y-920

attachment

cc: G. A. Harrison, NRC Clinton Licensing Project Manager
NRC Resident Office
Illinois Department of Nuclear Safety

~~8402070152~~

71 pp.

CLINTON POWER STATION
TRANSPORTATION ACCIDENTS
SER OUTSTANDING ISSUE #1

PRESENTATION OUTLINE

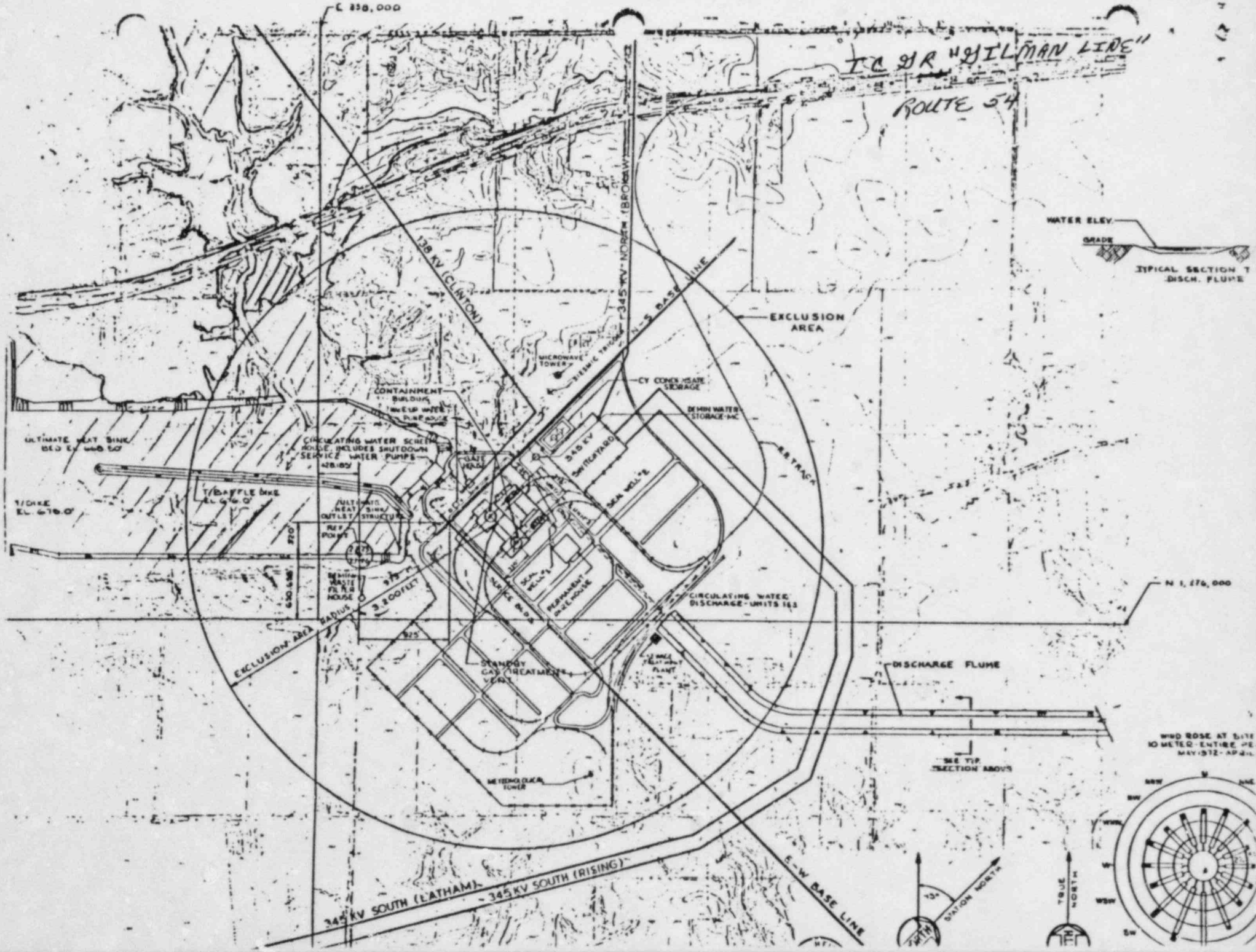
1.	GENERAL INTRODUCTION	D. HOLTZSCHER
	-SER ISSUE BACKGROUND	
	-SITE/PLANT LAYOUT	
2.	TOXIC HAZARDS ANALYSIS	R. RIPPY
	-DATA COLLECTION	
	-SCREENING OF CHEMICALS	
	-HAZCHEM	P. SCHOLL
	-TOXIC LIMITS	
	-PROBABILITY RISK ASSESSMENT	T. RILEY
	-ANALYSIS CONSERVATISMS	
	-CONCLUSIONS	
3.	EXPLOSIVE HAZARDS ANALYSIS	J. DOYLE
	-DATA COLLECTION	
	-BASIC ASSUMPTIONS	
	-PROBABILITY CALCULATION	
	-ANALYSIS CONSERVATISMS	T. RILEY
	-CONCLUSIONS	
4.	CONCLUDING COMMENTS/REGULATORY COMPLIANCE	D. HOLTZSCHER

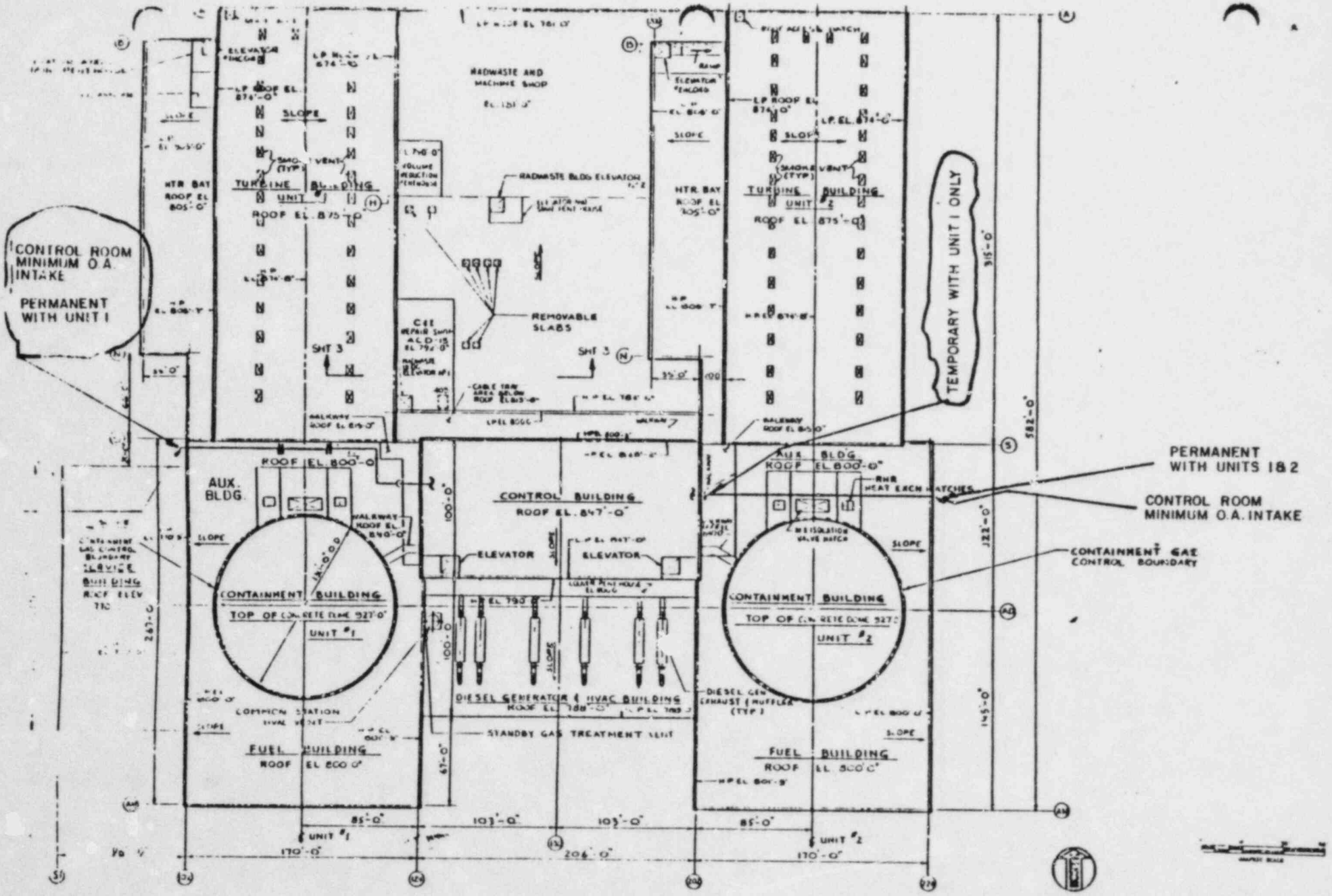
TRANSPORTATION ACCIDENTS
SER OUTSTANDING ISSUE #1
BACKGROUND

- CPS SER (NUREG-0853) SECTION 2.2.1 - TRANSPORTATION ROUTES:

  "THE NEAREST RAILROAD IS A LINE OF THE ILLINOIS CENTRAL GULF RAILROAD WHICH RUNS PARALLEL TO STATE ROUTE 54 AND TRAVERSES THE SITE APPROXIMATELY 0.75 MI (1.21 KM) NORTH OF THE STATION. THE ILLINOIS CENTRAL GULF RAILROAD ALSO HAS A LINE APPROXIMATELY 3.5 MI (5.6 KM) SOUTH OF THE STATION. THE HAZARDS ASSOCIATED WITH RAIL TRANSPORTATION OF TOXIC AND EXPLOSIVE MATERIALS ARE STILL BEING EVALUATED. BASED ON 1976 AND 1980 TRANSPORTATION DATA OBTAINED FROM ILLINOIS CENTRAL GULF RAILROAD, THE APPLICANT HAS IDENTIFIED SEVERAL MATERIALS REQUIRING FURTHER ANALYSIS. THESE WILL BE ADDRESSED IN A FUTURE SER SUPPLEMENT."

- ILLINOIS POWER COMPANY RESPONSES
  - LETTER MAY 28, 1982:
    - -RUPTURE PROBABILITY FOR ICGR UNREALISTIC.
    - -DELAYED IGNITION OF VAPOR CLOUD REQUIRED CLARIFICATION.
  - LETTER MARCH 4, 1983:
    - -USED NATIONAL SHIPPING DATA FOR RUPTURE PROBABILITY
    - -USED IP SURVEY DATA FOR SHIPPING FREQUENCY
    - -EXPANDED DESCRIPTION OF DELAYED IGNITION EVALUATION
  - LETTER AUGUST 26, 1983: ADDITIONAL INFORMATION ON TOXICITY LIMITS.
  - LETTER SEPTEMBER 16, 1983: DISCUSSION ON CONSERVATISMS.


E 838,000
ROUTE 54
WATER ELEV.
GRADE
EXCLUSION AREA
138 KV (CLINTON)
345 KV NORTH (BROKAW)
N-S BASE LINE
MICROWAVE TOWER
CONTAINMENT BUILDING
CY CONES WASTE STORAGE
DEMIN WATER STORAGE-MC
345 KV SWITCHYARD
ULTIMATE HEAT SINK
CIRCULATING WATER SCREEN HOUSE, INCLUDES SHUTDOWN SERVICE WATER PUMPS
T/BAFFLE DIKE EL. 676.0'
T/DIKE EL. 678.0'
ULTIMATE HEAT SINK OUTLET STRUCTURE
INTAKE CANAL
SEAL WELL #2
SEAL WELL #1
PERMANENT DIKE-HOUSE
CIRCULATING WATER DISCHARGE-UNITS 1&2
N 1,276,000
3,200 FEET
EXCLUSION AREA RADIUS
STANDBY GAS TREATMENT PLANT
DISCHARGE FLUME
SEE TYP. SECTION ABOVE
METEOROLOGICAL TOWER
345 KV SOUTH (LATHAM)
345 KV SOUTH (RISING)
E-W BASE LINE
STATION NORTH
TRUE NORTH
TYPICAL SECTION T
DISCH. FLUME
WIND ROSE AT SITE
10 METER - ENTIRE PE
MAY 1972 - APRIL



CLINTON POWER STATION
FINAL SAFETY ANALYSIS REPOR

FIGURE 6.4-2

Control Room HVAC Design

- Unit 1 Control Room Volume - 294,000 ft^3
- Redundant Air Intakes Opposite sides of Plant - 375' Apart
- Isolation Capability
  - Auto Isolation
    - Smoke
    - Chlorine
  - Manual Isolation
    - Self-Detection
- Modes of Operation
  - Normal - 4000 cfm Makeup
  - High Radiation Condition - 3000 cfm Makeup
    - Makeup Filter
    - Recirculation Filter
  - Isolated - No Makeup
    - Recirculation Filter
- 100% Redundant Equipment Trains
- Internal Recirculation Filters
  - -Activated Charcoal 2700 lbs per bed
  - -57,000 cfm Capacity
- Bottled Air Supply
  - 6 hours supply for emergency staff (5 people)
  - Remote fill station outside

SLIDE 1

DATA COLLECTION

METHOD

- IPC PERFORMED COMPREHENSIVE SURVEY
  - -FROM ICG SHIPPING RECORDS
  - -SURVEY PERIOD: DECEMBER 1, 1981 TO NOVEMBER 30, 1982

- IDENTIFICATION OF HAZARDOUS MATERIALS
  - -DEFINITION OF "HAZARDOUS MATERIALS"
  - -IDENTIFICATION REQUIRED BY 49CFR "TRANSPORTATION"
  - -49-SERIES STANDARD TRANSPORTATION COMMODITY CODE (STCC) NUMBER

RESULTS

- 123 TYPES OF HAZARDOUS MATERIALS

- SUMMARIZED IN TABLE 1 OF MARCH 4, 1983 REPORT

SLIDE 2

SCREENING OF CHEMICALS

- SHIPPING FREQUENCY
- VAPOR PRESSURE
- SIMPLE ASPHYXIANTS
- LOW TOXICITY
- FURTHER ANALYSIS

SHIPPING FREQUENCY

- REG. GUIDE 1.78 CRITERION
- 19 CHEMICALS SHIPPED 30 OR MORE TIMES PER YEAR
- SUMMARIZED IN TABLE 2 OF REPORT (SLIDE 4)

VAPOR PRESSURE

- REG. GUIDE 1.78 CRITERION
- CHEMICALS ELIMINATED - VAPOR PRESSURE LESS THAN 10 TORR
  - -SULFURIC ACID
  - -MONOETHANOLAMINE
  - -CORROSIVE LIQUID N.O.S.
  - -SODIUM NITRATE (SOLID)

SLIDE 4

TABLE 2 (OF IP REPORT DATED 3/4/83)

HAZARDOUS MATERIALS SHIPMENTS WITH A FREQUENCY OF 30 OR MORE CARS PER YEAR OVER THE ILLINOIS CENTRAL GULF-GILMAN LINE, 12/1/81 TO 11/30/82

STCC No.	Description of Commodity	Carloads	Tons
4904210	Anhydrous Ammonia	37	3,119
4905706	Butane	443	31,146
4905707	Liquefied Petroleum Gas (butene gas, liquefied)	345	24,459
4905747	Isobutane	793	57,001
4905752	Liquefied Petroleum Gas	885	61,816
4905781	Propane	164	11,559
4905782	Propylene	801	57,132
4906620	Propylene Oxide	77	5,164
4907270	Vinyl Acetate	137	10.769
4909110	Alcohol, N.O.S. (ethyl alcohol, anhydrous, denatured in part with petroleum products and/or chemicals not to exceed five percent)	60	4,817
4909141	Denatured Alcohol	56	3,874
4913144	Formaldehyde (or) formalin solution (in containers over 100 gallons)	38	3,227
4915259	Petroleum Naphtha	47	3,468
4918746	Sodium Nitrate	34	1,980
4930040	Sulfuric Acid	156	13,831
4935665	Monoethanolamine	44	3,391
4936110	Bromine	34	1,340
4936540	Corrosive Liquid, N.O.S.	34	2,621
4940320	Carbon Tetrachloride	185	15,560

SIMPLE ASPHYXIANTS

- REG. GUIDE 1.78 CRITERION
  - -SIMPLE ASPHYXIANTS MAY BE ELIMINATED FROM CONSIDERATION UNLESS "A SIGNIFICANT FRACTION OF THE CONTROL ROOM AIR COULD BE DISPLACED AS A RESULT OF THEIR RELEASE".
- SAX CRITERION
  - -UP TO A THIRD OF THE AIR IN A ROOM CAN BE DISPLAYED BY A SIMPLE ASPHYXIANT BEFORE A HUMAN BEING WILL EXPERIENCE ADVERSE EFFECTS.
- ASPHYXIANTS ELIMINATED
  - -BUTANE
  - -PROPYLENE
  - -BUTENE

LOW TOXICITY

- SAX'S TOXICITY SCALE
  - -TOXICITY EVALUATED ON BASIS OF NUMERICAL SCALE: 1=SLIGHT TOXICITY, 2=MODERATE TOXICITY, 3:SEVERE TOXICITY
  - -CHEMICALS WITH ACUTE SYSTEMIC TOXICITY RATING OF 1 DUE TO INHALATION OR AS AN IRRITANT WERE NOT CONSIDERED SUFFICIENTLY TOXIC TO WARRANT FURTHER INVESTIGATION.
  - -CHEMICALS WITH A TOXICITY RATING OF 1 ARE SLIGHTLY TOXIC. THEY CAUSE SLIGHT CHANGES WHICH ARE READILY REVERSIBLE AND DISAPPEAR AT THE END OF EXPOSURE.
  - -THEY WILL NOT PREVENT A CONTROL ROOM OPERATOR FROM SAFELY OPERATING THE PLANT.
  - -ISOBUTANE AND PROPANE MET THIS QUALIFICATION.

SLIDE 7

- SAX'S CONCENTRATIONS FOR LONG EXPOSURES

  -SAX DOES NOT GIVE A TOXICITY RATING FOR LIQUID PETROLEUM GAS (LPG). DESCRIBED BY SAX AS "TOXICITY: UNKNOWN. MAY ACT AS A SIMPLE ASPHYXIANT."

  -SAX LISTED A THRESHOLD LIMIT VALVE (TLV) FOR LPG.

  -TLV: MAXIMUM CONCENTRATION OF A CHEMICAL TO WHICH A HUMAN CAN BE SAFELY EXPOSED FOR SEVERAL HOURS DAILY OVER LONG PERIODS OF TIME.

  -TOXIC LIMIT FOR ACUTE EXPOSURE (AS IN A TOXIC SPILL) WOULD BE MUCH HIGHER THAN TLV.

  -TLV FOR LPG = 1000 PPM
  - EQUAL TO TLV OF PROPANE
  - IMPLIES HIGH LEVEL OF HUMAN TOLERANCE

  LPG WAS CONSIDERED SUFFICIENTLY TOXIC TO WARRANT FURTHER INVESTIGATION.

FURTHER ANALYSIS

- 9 CHEMICALS REMAINING FOR FURTHER ANALYSIS
  - -PROPYLENE OXIDE
  - -VINYL ACETATE
  - -CARBON TETRACHLORIDE
  - -PETROLEUM NAPHTHA
  - -FORMALDEHYDE
  - -DENATURED ALCOHOL
  - -ALCOHOL N.O.S.
  - -ANHYDROUS AMMONIA
  - -BROMINE

CHEMICALS ANALYZED BY HAZCHEM

PROPYLENE OXIDE

VINYL ACETATE

CARBON TETRACHLORIDE

BROMINE

ANHYDROUS AMMONIA

PETROLEUM NAPHTHA

- PENTANE
- HEXANE
- HEPTANE

FORMALDEHYDE

- 37% AQUEOUS SOLUTION
- 50% AQUEOUS SOLUTION

DENATURED ALCOHOL/ALCOHOL, NOS

- ETHYL ALCOHOL BASE
- SEVERAL DENATURANTS

THE HAZCHEM PROGRAM

- Calculates chemical concentration from a distant source
- Based on R. G. 1.78 diffusion analysis
- Validated by Sargent & Lundy
- Two Versions:
  - Gas
  - Liquid

HAZCHEM INPUTS

- Distance from release to plant
- Amount of chemical spilled
- Chemical properties
- Weather conditions
- Control room ventilation characteristics

HAZCHEM OUTPUTS

- Chemical concentration at control room intake
- Chemical concentration inside control room

HAZCHEM PROGRAM

APPLIED ASSUMPTIONS

- RELEASE OF MAXIMUM RECORDED TANK CAR WEIGHT
- INSTANTANEOUS RELEASE OF TOTAL CAR CONTENTS
- RELEASE AT POINT ON RAILROAD NEAREST PLANT
- GROUND RELEASE OF CHEMICAL
- CONTROL ROOM INTAKE DIRECTLY DOWNWIND OF RELEASE
- PUFF CENTER (MOST CONCENTRATED POINT) AT CONTROL ROOM INTAKE
- PASQUILL STABILITY CLASS F (VERY STABLE) PER R. G. 1.78
- FOR GASES, INSTANTANEOUS RELEASE PER PUFF MODEL OF R. G. 1.78
- FOR LIQUIDS, CONTINUOUS EVAPORATION BASED ON CHEMICAL PROPERTIES AND GUIDELINES OF R. G. 1.78

DETERMINATION OF CHEMICAL HAZARDS

IF HAZCHEM CONCENTRATION LESS THAN ACUTE EXPOSURE TOXICITY LIMIT, THEN THE CHEMICAL IS NOT HAZARDOUS.

NOTE: TOXICITY LIMITS WERE CONSERVATIVELY COMPARED WITH CALCULATED CONCENTRATIONS AT THE CONTROL ROOM INTAKE (WHICH ARE HIGHER THAN INSIDE THE CONTROL ROOM).

DEFINITIONS OF TOXICITY LIMIT TERMS

ACUTE EXPOSURE TOXICITY LIMIT - CHEMICAL CONCENTRATION RESULTING IN HUMAN DISCOMFORT OR INCAPACITATION AFTER A FEW HOURS OF EXPOSURE.

THRESHOLD LIMIT VALUE (TLV) - CHEMICAL CONCENTRATION TO WHICH WORKERS MAY BE EXPOSED DAILY WITHOUT ADVERSE EFFECTS.

TIME WEIGHTED AVERAGE (TWA) - CHEMICAL CONCENTRATION ACCEPTABLE FOR LENGTHLY EXPOSURES, CALCULATED BY AVERAGING CONCENTRATION OVER TIME.

METHODOLOGY FOR DETERMINING TOXICITY LIMITS

- BECAUSE OPERATOR EXPOSURE TO A RELEASED CHEMICAL WOULD BE OF SHORT DURATION (A FEW HOURS), ACUTE EXPOSURE TOXICITY LIMITS ARE APPLICABLE.

- ACUTE EXPOSURE LIMITS ARE NOT OFTEN AVAILABLE IN TOXICITY LITERATURE.

- WHERE ACUTE EXPOSURE LIMITS WERE UNAVAILABLE, EITHER THE TWA OR 2xTLV WERE USED AS CONSERVATIVE APPROXIMATIONS.

ACUTE EXPOSURE TOXICITY LIMITS

ACUTE EXPOSURE LIMITS PER R.G. 1.78 OR TOXICOLOGY REFERENCES FOR THE FOLLOWING:

CHEMICAL	ACUTE EXPOSURE LIMIT (PPM)
PROPYLENE OXIDE	1500
CARBON TETRACHLORIDE	1500
FORMALDEHYDE	10
ETHYL ALCOHOL (DENATURED ALCOHOL)	5000
CHLOROFORM (DENATURANT)	2000
EHHYL ETHER (DENATURANT)	800

TIME WEIGHTED AVERAGE (TWA)

THE TIME WEIGHTED AVERAGE CONCENTRATION WAS USED AS AN ESTIMATE OF THE ACUTE EXPOSURE LIMIT FOR THE FOLLOWING:

CHEMICAL	TWA (PPM)
HEXANE (PETROLEUM NAPHTHA)	500

THRESHOLD LIMIT VALUE (TLV)

TWO TIMES THE THRESHOLD LIMIT VALUE (2xTLV) WAS USED TO ESTIMATE ACUTE EXPOSURE LIMITS FOR THE FOLLOWING:

CHEMICAL	2xTLV (PPM)
PENTANE (PETROLEUM NAPHTHA)	1200
HEPTANE (PETROLEUM NAPHTHA)	800
METHYL ALCOHOL (DENATURANT)	400
BENZENE (DENATURANT)	50
BUTYL ALCOHOL (DENATURANT)	200
METHYL ISOBUTYL KETONE (DENATURANT)	200
TOLUENE (DENATURANT)	400

CONSERVATISM IN THE USE OF TWA AND 2XTLV

USE OF TWA IS CONSERVATIVE SINCE IT IS FOR LENGTHY EXPOSURES.

USE OF 2XTLV IS ALSO CONSERVATIVE BECAUSE:

- CHEMICAL CONCENTRATIONS TOLERABLE ON A DAILY BASIS SHOULD BE TOLERABLE IN AT LEAST DOUBLE CONCENTRATIONS FOR A FEW HOURS.
- CHEMICALS WITH KNOWN ACUTE LIMITS AND KNOWN TLV SHOW A RATIO BETWEEN ACUTE LIMITS AND TLV GREATER THAN 2:1. FOR EXAMPLE:

CHEMICAL	ACUTE LIMIT (PPM)	TLV (PPM)	RATIO-ACUTE LIMIT: TLV
PROPYLENE OXIDE	1500	100	15:1
CARBON TETRACHLORIDE	1500	10	150:1
CHLOROFORM	2000	50	40:1

- THE USE OF 2XTLV IS CONSISTENT WITH TOXICITY LIMITS LISTED IN TABLE C-1 OF REGULATORY GUIDE 1.78.

HAZCHEM RESULTS

Non-Hazardous Chemicals

Propylene Oxide

Vinyl Acetate

Carbon Tetrachloride

Petroleum Naphtha

Formaldehyde

Denatured Alcohol and Alcohol, NOS

Potentially Hazardous Chemicals

Bromine

Anhydrous Ammonia

Table 3

HAZCHEM CALCULATIONS OF TOXIC CHEMICAL CONCENTRATIONS AT CLINTON STATION

CHEMICAL	AMOUNT OF * CHEMICAL EVALUATED	CONCENTRATION AT CONTROL ROOM INTAKE CALCULATED BY HAZCHEM	MAXIMUM ALLOWABLE CONCENTRATION FOR ACUTE EXPOSURES	REFERENCE/COMMENTS
Propylene Oxide	121 tons	0.843×10^{-4} lb/ft^3 (562 ppm)	0.225×10^{-3} lb/ft^3 (1500 ppm)	Reference 5
Vinyl Acetate	101 tons	0.171×10^{-4} lb/ft^3 (77 ppm)	No acute exposure limits were found	Reference 6 (reports it to be a "relatively non-toxic material.")
Carbon Tetrachloride	130 tons	0.442×10^{-4} lb/ft^3 (109 ppm)	0.609×10^{-3} lb/ft^3 (1500 ppm)	Reference 3
Pentane (Petroleum Naphtha)	97 tons	0.1707×10^{-3} lb/ft^3 (927 ppm)	0.221×10^{-3} lb/ft^3 (1200 ppm) = 2 x TLV**	Reference 7
Hexane (Petroleum Naphtha)	97 tons	0.5097×10^{-4} lb/ft^3 (232 ppm)	1.10×10^{-4} lb/ft^3 (500 ppm) = TWA**	Reference 7
Heptane (Petroleum Naphtha)	97 tons	0.2371×10^{-4} lb/ft^3 (95 ppm)	2.00×10^{-4} lb/ft^3 (800 ppm) = 2 x TLV**	Reference 7
37% Formaldehyde (Formalin)	98 tons	0.4496×10^{-7} lb/ft^3 (0.6 ppm)	7.49×10^{-7} lb/ft^3 (10 ppm)	References 2,
50% Formaldehyde	98 tons	0.5941×10^{-7} lb/ft^3 (0.8 ppm)	7.49×10^{-7} lb/ft^3 (10 ppm)	References 2,
Ethyl Alcohol	100 tons	0.497×10^{-5} lb/ft^3 (42 ppm)	0.587×10^{-3} lb/ft^3 (5000 ppm)	References 2,

* Maximum Shipping Weight from survey.

** If an acute exposure limit could not be found, a value of 2 x TLV (Threshold Limit Valve for an 8-hour, daily exposure) or the TWA (Time Weighted Average for lengthy exposure) was used. These

TABLE 4

HAZCHEM CALCULATIONS OF TOXIC CHEMICAL CONCENTRATIONS AT CLINTON STATION

CHEMICAL	AMOUNT OF CHEMICAL EVALUATED	CONCENTRATION AT CONTROL ROOM INTAKE CALCULATED BY HAZCHEM	MAXIMUM ALLOWABLE CONCENTRATION FOR ACUTE EXPOSURES
Methyl Alcohol(as a worst case for denatured alcohol)	100 tons	0.2234×10^{-4} lb/ft^3 (296 ppm)	2 x TLV* = 0.3015×10^{-4} lb/ft^3 (400 ppm)

DENATURED ALCOHOL: Concentrations at the control room intake for the following denaturants were estimated by scaling down the concentration for a 100-ton methyl alcohol spill to the maximum amount of each denaturant found in 100 tons of denatured ethyl alcohol.

DENATURANT	MAXIMUM % BY WEIGHT IN ETHYL ALCOHOL FOUND IN LITERATURE	CONCENTRATION AT CONTROL ROOM INTAKE FOR AN EQUIVALENT AMOUNT OF METHANOL	MAXIMUM ALLOWABLE CONCENTRATION FOR ACUTE EXPOSURES
Benzene	5.27%	13 ppm	2 x TLV* = 20 ppm
Butyl Alcohol	2.79%	7 ppm	2 x TLV* = 200 ppm
Chloroform	8.5%	12 ppm	2000 ppm
Ethyl Ether	8.15%	25 ppm	800 ppm
Formaldehyde	4.37%	8 ppm	10 ppm
Heptane	5%	16 ppm	2 x TLV* = 1000 ppm
Methyl Isobutyl Ketone	5%	14 ppm	2 x TLV* = 200 ppm
Toluene	5.07%	13 ppm	2 x TLV* = 400 ppm

* If an actue exposure limit could not be found, a value of 2 x TLV (Threshold Limit Value for an 8-hour, daily exposure) was used. This value is very conservative.

NOTE: All denaturant maximum allowable concentrations were taken from Reference 3, except for formaldehyde, which was taken from Reference 2.

Clinton Power Station
Toxic Hazards Analysis
Probability Risk Assessment

- Following "Hazchem" diffusion analysis, two chemicals remained for further evaluation:
  - Anhydrous Ammonia
  - Bromine

- NUREG-0800 (Standard Review Plan)
  Section 2.2.3 provides criteria for Design Basis Events:

  "The probability of occurrence of the initiating events leading to potential consequences in excess of 10 CFR Part 100 exposure guidelines should be estimated using assumptions that are as representative of the specific site as is practicable. In addition, because of the low probabilities of the events under consideration, data are often not available to permit accurate calculation of probabilities. Accordingly, the expected rate of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines of approximately 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower."

- CPS Risk Assessment Analysis utilizes two conservative and cross-checking methods:
  - Method #1 - Probability of release per car mile and shipping frequency in cars per year.

$$P_A = P_R(C) \cdot F(C) \cdot \left[\sum_{D=1}^{8} L(D) \cdot P_W(D) \right]$$

Where,

P_A = probability of an accident $\left[\frac{\text{releases}}{\text{year}}\right]$

$P_R(C)$ = probability of release $\left[\frac{\text{releases}}{\text{car-mile}}\right]$

$F(C)$ = frequency of shipment $\left[\frac{\text{cars}}{\text{year}}\right]$

$L(D)$ = length of track segment [miles]

$P_W(D)$ = wind probability [dimensionless]

"D" is wind direction

"C" is cars

- METHOD #2 - PROBABILITY OF RELEASE PER TON MILE AND SHIPPING FREQUENCY IN TONS PER YEAR.

$$P_A = P_R(T) \cdot F(T) \cdot \left[\sum_{D=1}^{8} L(D) \cdot P_W(D)\right]$$

TERMS AS DEFINED BEFORE EXCEPT "T" IS TONS.

- QUANTIFICATION OF TERMS
  - ACCIDENT RELEASE FREQUENCIES

    ANHYDROUS AMMONIA (NON-FLAMMABLE GAS)

    $P_R(C) = 0.019 \times 10^{-6} \left[\frac{\text{RELEASES}}{\text{CAR-MILE}}\right]$

    $P_R(T) = 0.27 \times 10^{-9} \left[\frac{\text{RELEASES}}{\text{TON-MILE}}\right]$

    BROMINE (CORROSIVE)

    $P_R(C) = 0.090 \times 10^{-6} \left[\frac{\text{RELEASES}}{\text{CAR-MILE}}\right]$

    $P_R(T) = 1.10 \times 10^{-9} \left[\frac{\text{RELEASES}}{\text{TON-MILE}}\right]$

  - SHIPPING FREQUENCIES

    ANHYDROUS AMMONIA

    $F(C) = 37 \left[\frac{\text{CARS}}{\text{YEAR}}\right]$

    $F(T) = 3119 \left[\frac{\text{TONS}}{\text{YEAR}}\right]$

TABLE 5 (OF IP REPORT DATED 3/4/83)

ACCIDENT FREQUENCIES PER MILLION CAR-MILES
FOR HAZARDOUS MATERIALS COMMODITIES

	DAMAGE THRESHOLD		
	$0	>$100	>$5000
Explosives	1.30	0.63	0.210
Non-Flammable Gas	1.00	0.15	0.019*
Flammable Gas	0.94	0.20	0.094
Flammable Liquid	1.20	0.32	0.110
Flammable Solid	0.69	0.17	0.058
Oxidizer	1.60	0.66	0.069
Organic Peroxide	1.40	1.40	-
Toxic	1.10	0.43	0.079
Radioactive	3.00	1.30	0.420
Corrosive	2.50	0.45	0.090**
All Hazardous Material	1.40	0.33	0.086

* ammonia is classified as a non-flammable gas

** bromine is classified as a corrosive

SOURCE: Materials Transportation Board Data 1971-77;
Arthur D. Little, Inc., Estimates

Excerpted from USDOT FRA/ORD-79/56 (Reference 11)

TABLE 6 (OF IP REPORT DATED 3/4/83)

ACCIDENT FREQUENCIES PER BILLION TON-MILES
FOR HAZARDOUS MATERIALS COMMODITIES

	Damage Threshold		
	$0	>$100	>$5000
Explosives	26.0	13.0	4.30
Non-Flammable Gas	15.0	2.2	0.27*
Flammable Gas	13.0	2.7	1.30
Flammable Liquid	17.0	4.7	1.60
Flammable Solid	11.0	2.9	0.95
Oxidizer	21.0	8.8	0.91
Organic Peroxide	17.0	18.0	-
Toxic	18.0	7.3	1.30
Radioactive	66.0	28.0	9.40
Corrosive	31.0	5.6	1.10**
All Hazardous Material	20.0	4.7	1.20

* ammonia is classified as a non-flammable gas
** bromine is classified as a corrosive

SOURCE: Materials Transportation Board Data 1971-77;
Arthur D. Little Inc., Estimates

Excerpted from USDOT FRA/ORD-79/56 (Reference 11)

BROMINE

$F(C) = 34 \left[\frac{\text{CARS}}{\text{YEAR}}\right]$

$F(T) = 1340 \left[\frac{\text{TONS}}{\text{YEAR}}\right]$

- TRACK SEGMENT/WIND PROBABILITY FACTOR

$$\sum_{D=1}^{8} L(D) \cdot PW(D) = 0.5769 \quad [\text{MILES}]$$

- RESULTS OF CALCULATIONS

TOXIC MATERIAL	RELEASE PROBABILITY $\left[\frac{\text{RELEASE}}{\text{YEAR}}\right]$ CAR-MILE BASIS	TON-MILE BASIS
ANHYDROUS AMMONIA	4.06×10^{-7}	4.86×10^{-7}
BROMINE	1.77×10^{-6}	8.50×10^{-7}
TOTAL TOXIC HAZARD	2.18×10^{-6}	1.34×10^{-6}

▶ DEMONSTRATES THAT POTENTIAL RATES OF OCCURRENCE ARE APPROXIMATELY 10^{-6} OR LESS.

TABLE 7 (OF IP REPORT DATED 3/4/83)

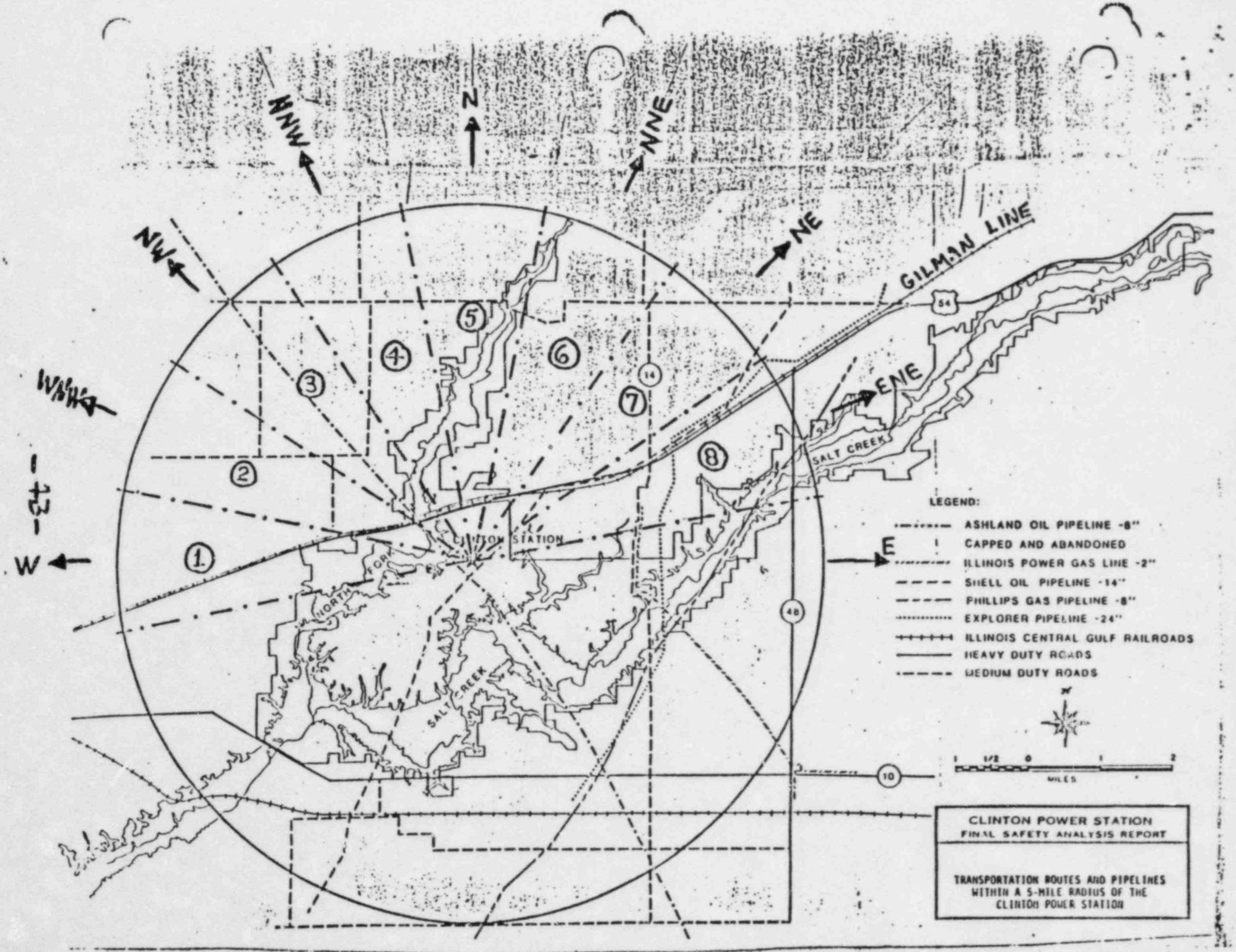
Σ L(D) x Pw(D) CALCULATION

Track Segment	Segment Length L(D) (miles)+	Wind Direction D	Wind Probability* Pw(D) (dimensionless)	L(D) x Pw(D) (miles)
1	3.30	W	0.0770	0.2541
2	0.90	WNW	0.0792	0.0713
3	0.46	NW	0.0584	0.0268
4	0.34	NNW	0.0438	0.0149
5	0.35	N	0.0425	0.0149
6	0.45	NNW	0.0405	0.0182
7	0.80	NE	0.0528	0.0422
8	3.10	ENE	0.0434	0.1345
Total	9.70			0.5769

Σ L(D) x Pw(D) = 0.5769 miles

+Denotes length of track in wind direction section under consideration (see figure 2)

*Pw(D) = Probability that a wind of any stability class and any velocity class is blowing toward the control room air intake (from Table 8).


NNW
N
NNE
NW
NE
GILMAN LINE
WNW
ENE
E
W
-43-
SALT CREEK
CLINTON STATION
NORTH FORK
SALT CREEK
LEGEND:
ASHLAND OIL PIPELINE -8"
CAPPED AND ABANDONED
ILLINOIS POWER GAS LINE -2"
SHELL OIL PIPELINE -14"
PHILLIPS GAS PIPELINE -8"
EXPLORER PIPELINE -24"
ILLINOIS CENTRAL GULF RAILROADS
HEAVY DUTY ROADS
MEDIUM DUTY ROADS
MILES
CLINTON POWER STATION
FINAL SAFETY ANALYSIS REPORT
TRANSPORTATION ROUTES AND PIPELINES WITHIN A 5-MILE RADIUS OF THE CLINTON POWER STATION

- Conservative Basis for CPS Toxic Hazards Analysis
  - Screening of Chemicals
  - Hazchem
  - Toxic Limits
  - Probability Risk Assessment
  - Additional Important Conservatisms

Conservative Basis for CPS Toxic Hazards Analysis

- Screening of Chemicals (comprehensive)
  - "Hazardous Materials" - shipping category which includes toxic materials. All hazardous materials initially considered toxic and then examined individually to determine if actual health hazard exists (in control room).
  - Shipping Frequency - Regulatory Guide 1.78 Criteria: Hazardous materials shipped by rail 30 or more times per year.

Conservative Basis for CPS Toxic Hazards Analysis

- "HAZCHEM" Diffusion Analysis
  - Instantaneous spill of total contents of tank car - R.G. 1.78 "Maximum Concentration Accident".
  - Control room intake modeled as directly downwind of the point of chemical release with no intervening structures.
  - Finite volume "puff" release model. Atmospheric dilution in Appendix B of R.G. 1.78. No cloud diffusion in the vertical centers puff at the control room air intake.
  - For all chemicals considered the amount (tons) evaluated was the Maximum Shipping Weight from the Clinton Survey. Not all cars, of each chemical surveyed, weighed the maximum amount.

    E.G. Bromine Max. Shipping Weight = 65 Tons

    Avg. Shipping Weight = 39 Tons

Conservative Basis for CPS Toxic Hazards Analysis

- Toxicity Limits
  - Detailed literature search performed.
  - Acute exposure limits used where data was available. Otherwise, TWA or 2-TLV used. In any case, the toxicity limit was then compared to the HAZCHEM calculated concentration to evaluate control room habitability.
  - Use of TWA (for lengthy exposures) is obviously conservative when applied to acute exposures (short-term).
  - 2-TLV: Chemical concentration tolerable on a daily basis is tolerable at 2-TLV for an acute exposure.
  - Comparison with known toxicity limits.
  - Comparison with Table C-1 in R.G. 1.78.

FOR THE FOLLOWING CHEMICALS, BOTH THE ACUTE EXPOSURE LIMITS AND THE TLV ARE KNOWN AND COMPARED:

CHEMICAL	ACUTE EXPOSURE TOXICITY LIMIT	TLV	RATIO-ACUTE EXPOSURE LIMIT: TLV
PROPYLENE OXIDE	1500 PPM	100 PPM	15:1
CARBON TETRACHLORIDE	1500 PPM	10 PPM	150:1
CHLOROFORM	2000 PPM	50 PPM	40:1

THE FOLLOWING TOXICITY LIMIT VS. TLV COMPARISONS ARE MADE WITH R.G. 1.78, TABLE C-1:

CHEMICAL	REGULATORY GUIDE TOXICITY LIMIT, PPM	TLV, PPM	RATIO REG. GUIDE LIMIT: TLV
ACETALDEHYDE	200	200	1:1
ACETONE	2,000	1,000	2:1
ACRYLONITRILE	40	20	2:1
ANHYDROUS AMMONIA	100	50	2:1
ANILINE	10	5	2:1
BENZENE	50	25	2:1
BUTADIENE	1,000	1,000	1:1
BUTENES	ASPHYXIANT	-	-
CARBON DIOXIDE	10,000	5,000	2:1
CARBON MONOXIDE	1,000	50	20:1
CHLORINE	15	1	15:1
ETHYL CHLORIDE	10,000	1,000	10:1
ETHYL ETHER	800	400	2:1
ETHYLENE DICHLORIDE	100	50	2:1
ETHYLENE OXIDE	200	50	4:1
FLUORINE	2	0.1	20:1
FORMALDEHYDE	10	5	2:1
HELIUM	ASPHYXIANT	-	-
HYDROGEN CYANIDE	20	10	2:1
HYDROGEN SULFIDE	500	10	50:1
METHANOL	400	200	2:1
NITROGEN (COMPRESSED OR LIQ.)	ASPHYXIANT	-	-
SODIUM OXIDE	2 MG/M^3	TLV NOT FOUND	
SULFUR DIOXIDE	5	5	1:1
SULFURIC ACID	2 MG/M^3	1 MG/M^3	2:1
VINYL CHLORIDE	1,000	500	2:1
XYLENE	400	100	4:1

Conservative Basis for CPS Toxic Hazards Analysis

- Probability Risk Assessment
  - Release Probabilities

    -Taken from materials Transportation Board data, for damage thresholds in excess of $5,000.

    ▶ Not all releases causing $5,000 damage are major releases (i.e. R.G. 1.78 "maximum concentration accidents").

  - No credit was taken for unstable winds.

    Pw(D) includes Pasquill stability categories A, B, & C.

CONSERVATIVE BASIS FOR CPS TOXIC HAZARDS ANALYSIS

- PROBABILITY RISK ASSESSMENT (CONTINUED) . . . . . .

  - NO CREDIT WAS TAKEN FOR THE EFFECTS OF LAKE. SIGNIFICANTLY WARMER LAKE SURFACE, DURING NIGHTTIME AND WINTER, THAN SURROUNDING GROUND.

    ▶ ADDITIONAL DIFFUSION IN THE VERTICAL OVER LAKE.

  - TANK CAR MODIFICATIONS

    -RELEASE PROBABILITIES TAKEN FROM DATA BEFORE MODIFICATIONS WERE REQUIRED.

    -AMMONIA & BROMINE TANK CARS REQUIRED BY FEDERAL LAW (49CFR) TO BE RETROFIT WITH SAFETY FEATURES:

    1. HEAD SHIELDS - PUNCTURE RESISTANCE SYSTEM;
       AAR SAYS 85% REDUCTION IN RELEASES.
       FRA SAYS 50% REDUCTION IN RELEASES.

       AND/OR

    2. SHELVES ON COUPLERS - COUPLER RESTRAINT SYSTEM;
       AAR SAYS 60% REDUCTION IN ACCIDENTS.

CONSERVATIVE BASIS FOR CPS TOXIC HAZARDS ANALYSIS

- PROBABILITY RISK ASSESSMENT (CONTINUED) . . . . . .

  -NATIONAL TRANSPORTATION SAFETY BOARD ACCIDENT STUDY:
  ANALYSIS OF PAXTON, TEXAS RAIL ACCIDENT.
  21 OF 21 SHELF COUPLERS REMAINED COUPLED.

  IN ANOTHER ACCIDENT 5 CARS EQUIPPED WITH HEAD SHEILDS AND SHELF COUPLERS REMAINED INTACT.

  ▶ ENGINEERING ASSESSMENT: FACTOR OF 2X REDUCTION IN RELEASE PROBABILITIES

- PROBABILITY OF OPERATOR INCAPACITATION
  -NUREG/CR-2650 STUDY CONDUCTED BY SANDIA FOR NRC.
  ▶ FACTOR OF 10X REDUCTION IN OVERALL ACCIDENT PROBABILITY TO ACCOUNT FOR OPERATOR INCAPACITATION EVENTS NOT RESULTING IN EXCEEDING 10CFR100 RADIOACTIVITY RELEASE GUIDELINES.

- Conclusions - Toxic Hazards Analysis

  - Detailed study performed.
  - R.G. 1.78 criteria applied.
  - Industry data applied.
  - Conservatisms applied.
  - Results acceptable as compared to NUREG-0800.
  - Adjusted probabilities after application of quantified conservatisms (accident reduction)
    - -Tank car modifications (2x)
    - -Operator incapacitation (10x)

  ▶ Car-Mile basis = 1.09×10^{-7} per year

  ▶ Ton-Mile Basis = 6.7×10^{-8} per year

  Realistic Probabilities Even Less.

TABLE 1

FLAMMABLE COMPRESSED GAS SHIPMENTS OVER THE ILLINOIS CENTRAL GULF-GILMAN LINE, 12/1/81 to 11/30/82

STCC No.	Description of Commodity	Carloads	Tons
4905702	Butane (butane, impure for further refining)	9	675
4905703	Butadiene, inhibited (butadiene, impure for further refining)	1	75
4905706	Butane	443	31,146
4905707	Liquefied Petroleum Gas (butene gas, liquefied)	345	24,459
4905711	Liquefied Petroleum Gas (butylene, impure for further refining)	13	875
4905741	Liquefied Petroleum Gas (NIC)	1	75
4905747	Isobutane	793	57,001
4905748	Isobutylene	1	75
4905750	Isobutane (Isobutane for further refinery processing)	8	523
4905752	Liquefied Petroleum Gas	885	61,816
4905761	Methyl Chloride	3	141
4905781	Propane	164	11,559
4905782	Propylene	801	57,132
4905785	Trifluorochloroethylene	1	75
4905792	Vinyl Chloride	4	300
	Total	3472	245,927

STCC: Standard Transportation Commodity Code

NIC: Not in Code - commodity was coded with a STCC number which could not be identified from the STCC tariff. Commodity was assumed to be of the same family of nearest identifiable commodity by STCC number.

TANK CAR STATISTICS

49 ACCIDENTS

322,800,000 CAR-MILES

PROBABILITY OF TANK CAR ACCIDENT

$$\frac{49}{322,800,000} = 1.52 \times 10^{-7} \text{ ACCIDENTS/CAR-MILE}$$

DETONATION RATE

Loss of Lading Due to Mechanical Damage:

Accidents:	163
Detonations:	3
Years:	13

Loss of Lading Due to Fire:

Accidents:	49
Detonations:	0
Years:	6

Probability of Detonation if Accident Occurs:

$$\frac{3/13 + 0/6}{163/13 + 49/6} = 1.11 \times 10^{-2} \text{ Detonations/Accident}$$

EXAMPLE CALCULATION

SEGMENT:

No. 8

WIND:

STABILITY CLASS D

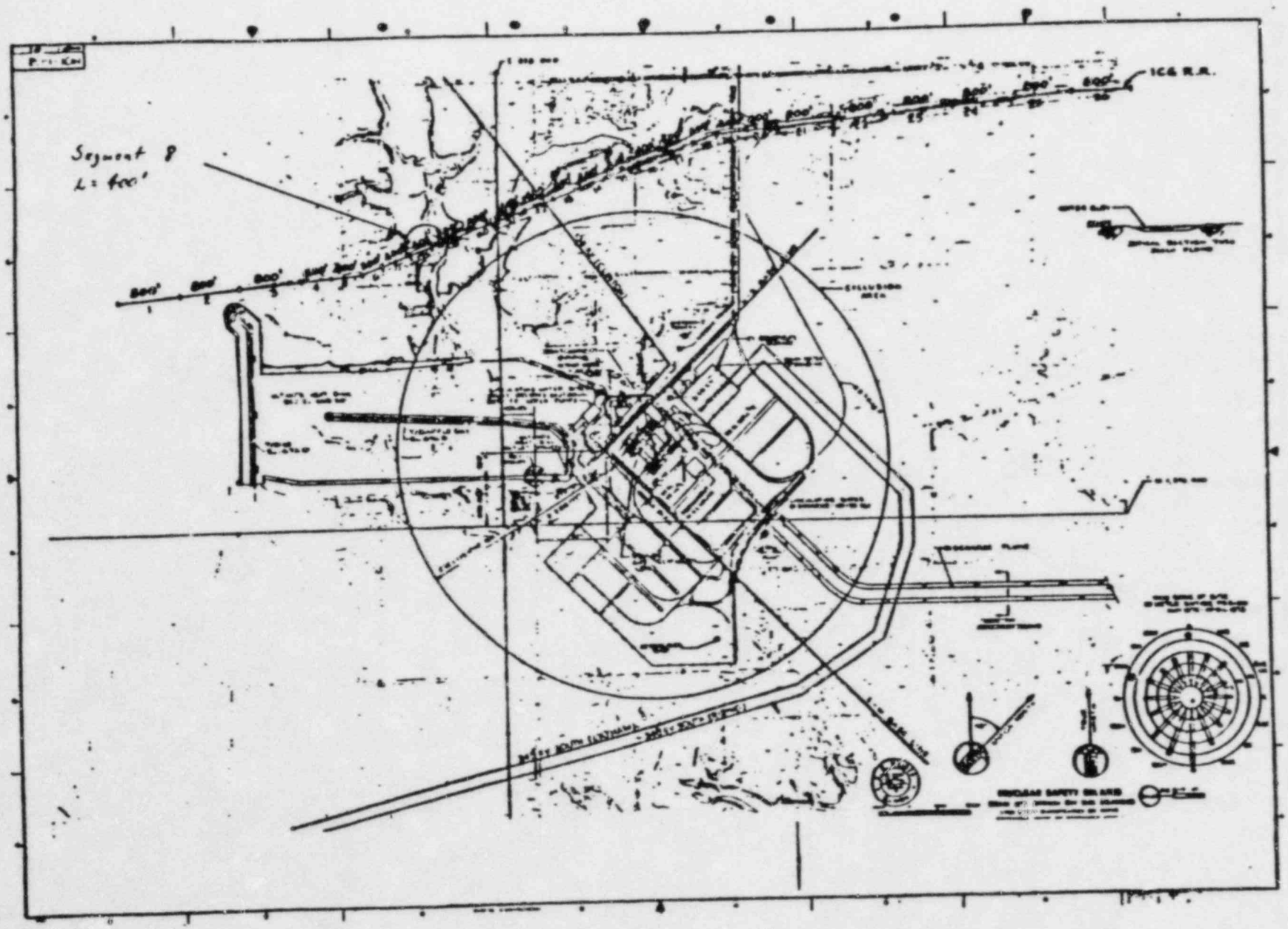
SPEED 1.5 - 3.0 M/SEC (AVE. 7.4 FPS)

TIME INTERVAL:

410 SEC. TO 610 SEC. AFTER ACCIDENT

DISCHARGE RATE:

2667 LB/SEC.


Segment 8
L= 600'
ICG R.R.

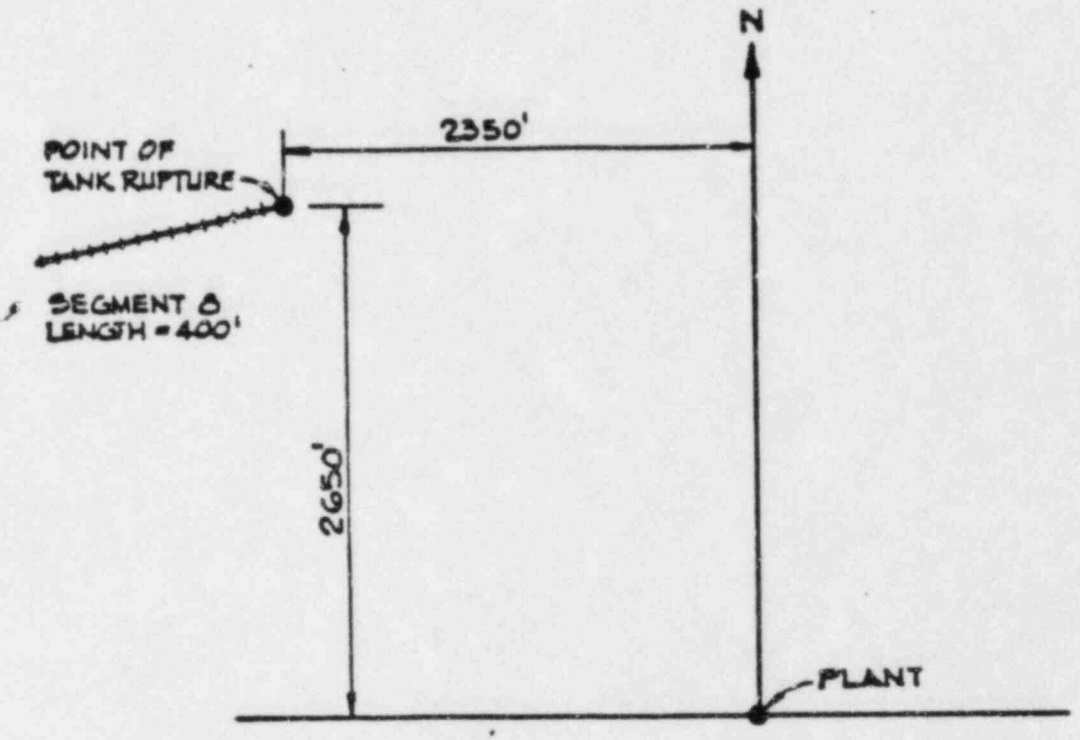


Figure 2: Isolated Segment 8 of Railroad Line

PROBABILITY OF ACCIDENT
IN SEGMENT 8

$$(1.52 \times 10^{-7})(400/5280)(3472) = 4 \times 10^{-5}$$

ASSUMED DISCHARGE RATES

OPENING DIAMETER, IN	DISCHARGE RATE, LB/SEC
23 1/2	2667
14 1/2	888.9
7 1/2	266.7
4 3/4	102.6

GAS CONCENTRATION

$$\psi(x,y,z) = \frac{Q}{\pi u \sigma_y \sigma_z} \exp\left(-\frac{y^2}{2\sigma_y^2} - \frac{z^2}{2\sigma_z^2}\right); \; u(t-T) \leq x \leq ut \qquad (4.4)$$

$$= 0 \quad x < u\,(t-T) \text{ and } x > ut$$

where the following symbols are used:

- ψ = gas concentration
- Q = gas release rate (ft^3/sec)
- u = wind velocity (ft/sec)
- x = distance downwind (ft)
- y = horizontal distance normal to drift direction (ft)
- z = vertical distance normal to drift direction (ft)
- σ_y = dispersion coefficient in horizontal direction (ft)
- σ_z = dispersion coefficient in vertical direction (ft)
- t = time after initial rupture (sec)
- T = time required for total content of car to be released (sec)

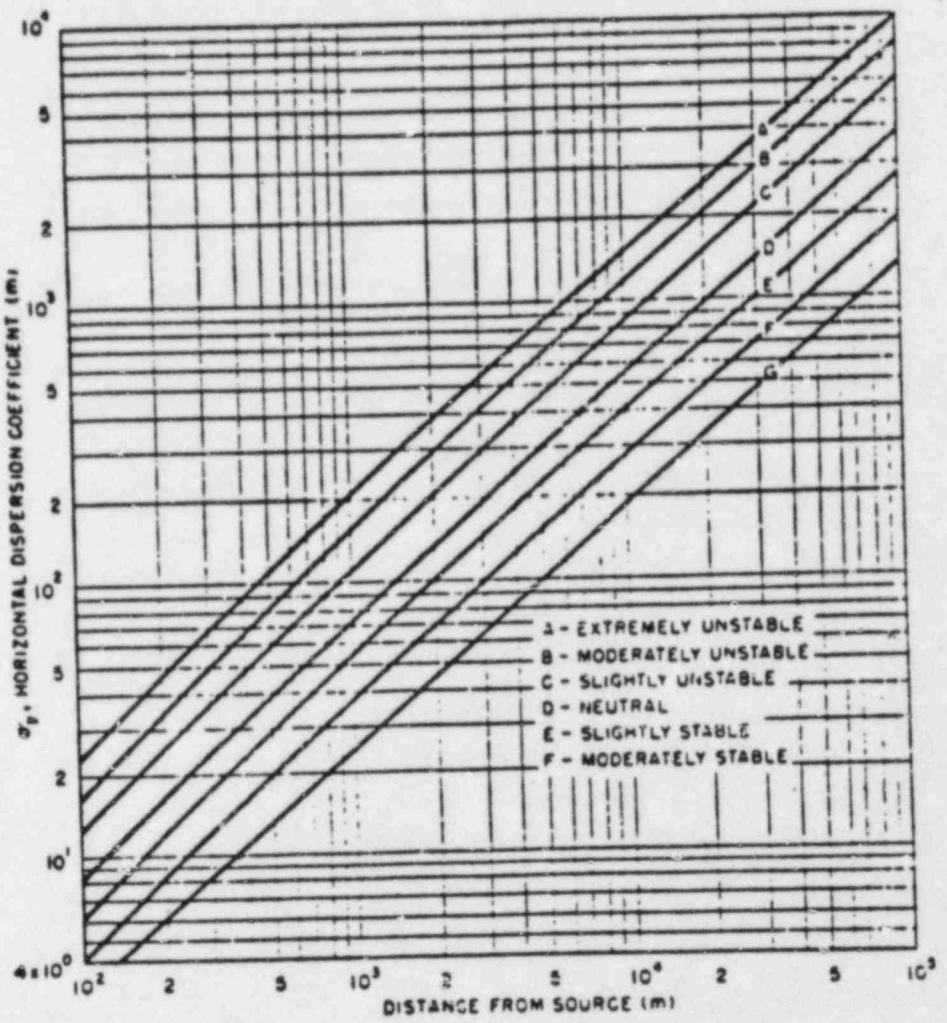


Figure 3: Horizontal Dispersion Coefficients

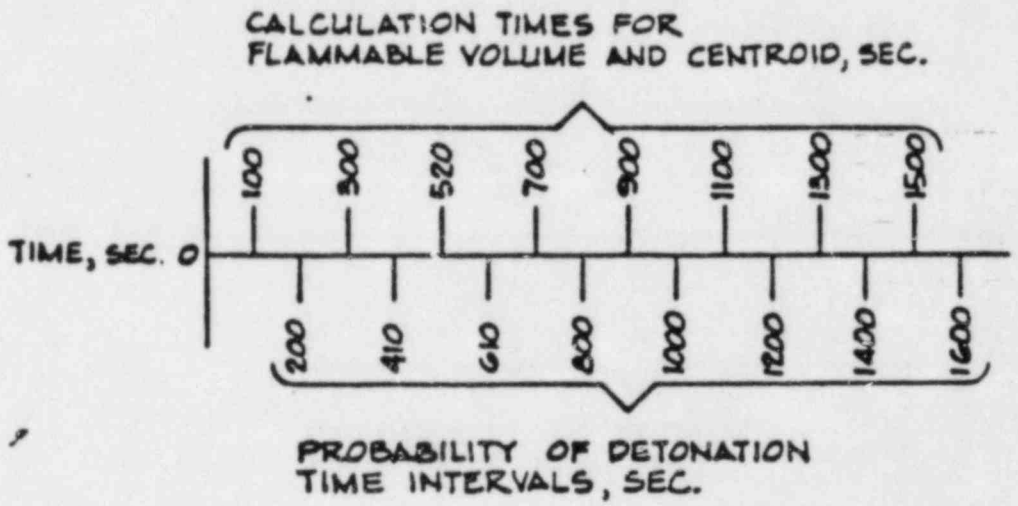


Figure 5: Time After Rupture for Calculation of Flammable Volume and Centroid Location; Time Intervals for Probability of Detonation Calculation, 1600 Second Duration

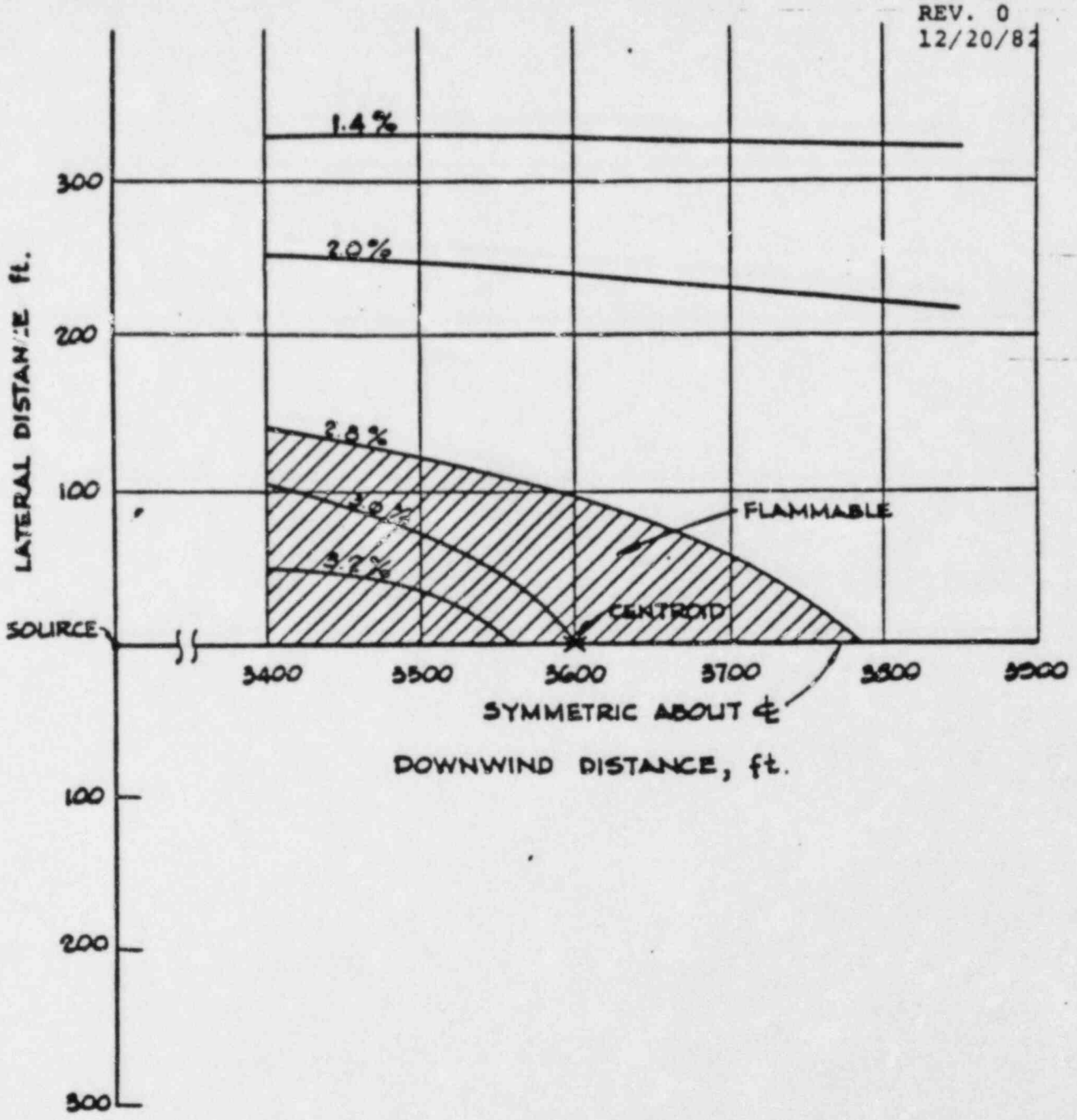
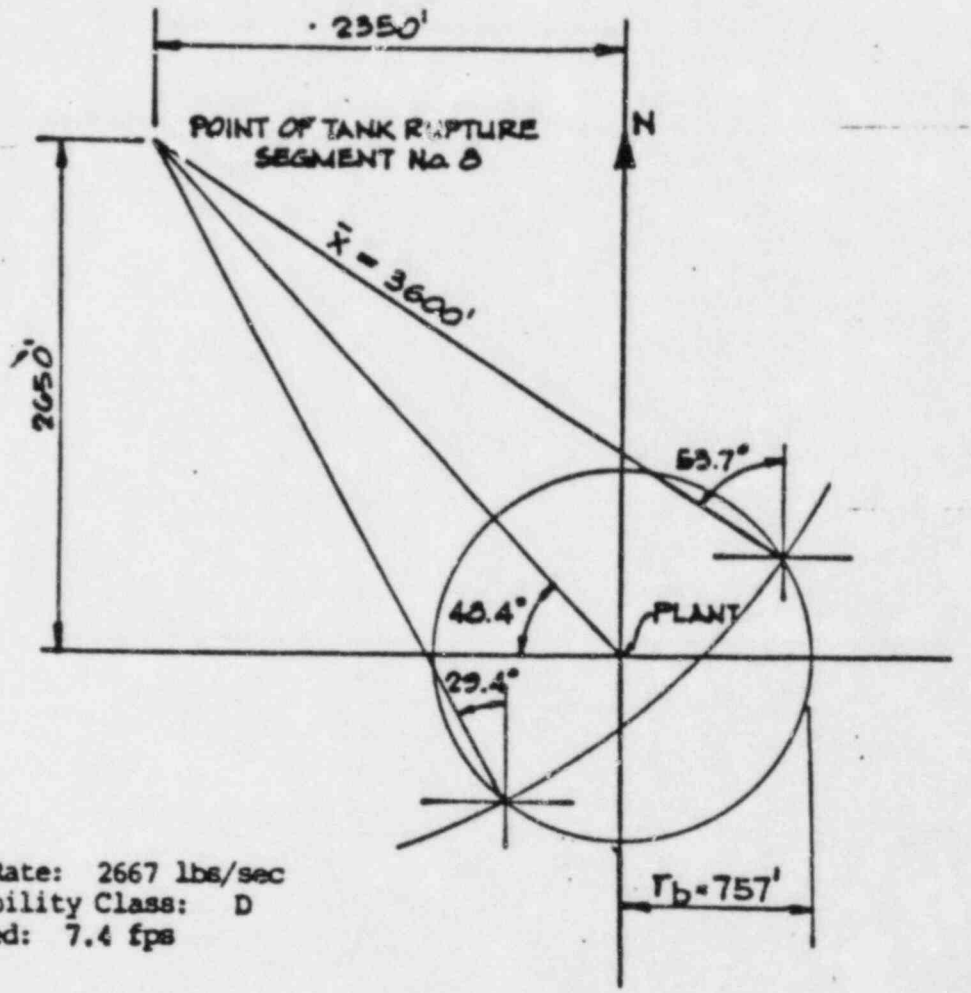


Figure 6: Ground Level Concentration at 520 Seconds After Rupture



Release Rate: 2667 lbs/sec
Wind Stability Class: D
Wind Speed: 7.4 fps

Figure 8: Geometric Considerations for Unfavorable Wind Direction

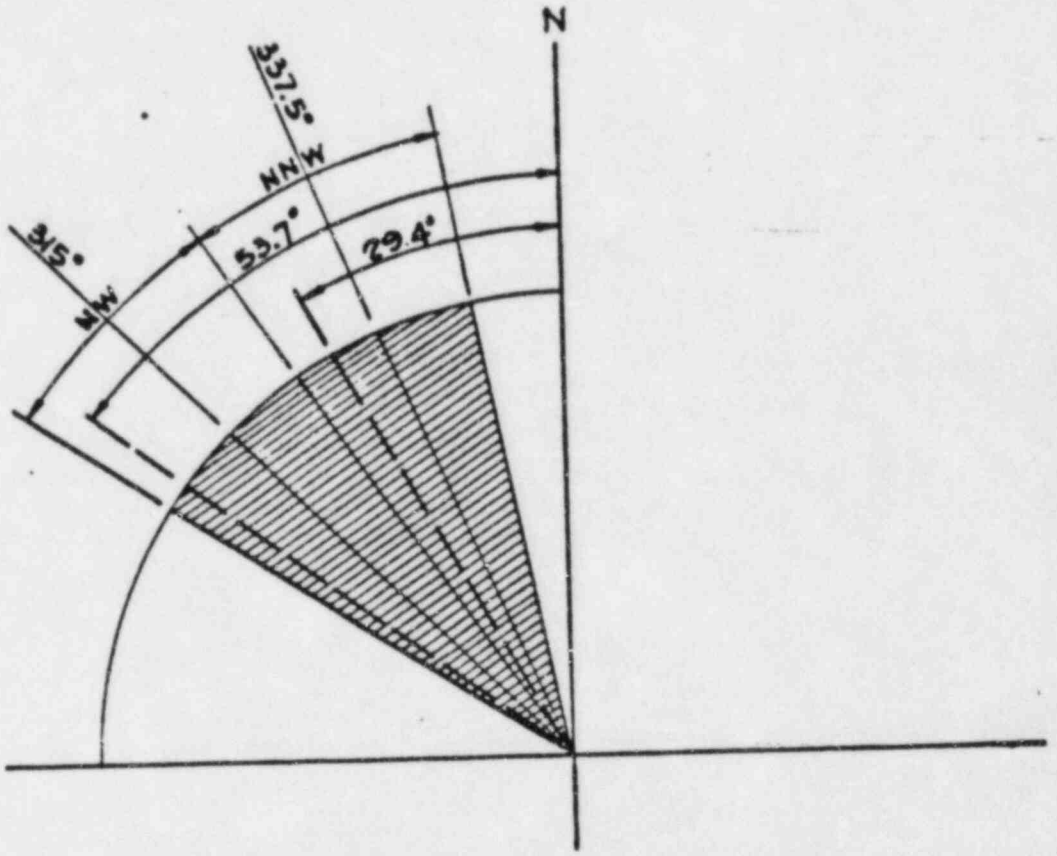


Figure 9: Determination of Applicable Wind Directions. Refer to Figure 8

TABLE 2.3-15

ONSITE STABILITY CLASS D JOINT FREQUENCY DISTRIBUTION FOR THE 10-METER HEIGHT (4/14/72-4/30/77)

	DIRECTION																
SPEED (MPS)	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
0.3- 1.9	30	34	31	37	43	25	46	50	46	52	37	36	46	26	35	31	602
(1)	0.18	0.21	0.19	0.23	0.25	0.15	0.28	0.31	0.28	0.32	0.23	0.22	0.28	0.16	0.21	0.19	3.69
(2)	0.07	0.08	0.08	0.09	0.10	0.06	0.11	0.12	0.11	0.13	0.09	0.09	0.11	0.06	0.09	0.08	1.48
1.9- 3.0	126	178	204	197	147	173	250	249	218	229	160	162	190	166	155	135	2939
(1)	0.77	1.09	1.25	1.21	0.90	1.06	1.53	1.53	1.34	1.40	0.98	0.99	1.16	1.02	0.95	0.83	18.01
(2)	0.31	0.44	0.50	0.48	0.36	0.43	0.61	0.61	0.54	0.56	0.39	0.40	0.47	0.41	0.38	0.33	7.23
3.1- 5.0	269	289	291	286	248	231	302	416	466	396	319	360	450	406	316	294	5334
(1)	1.65	1.77	1.78	1.75	1.52	1.42	1.85	2.55	2.85	2.43	1.92	2.21	2.76	2.49	1.94	1.80	32.69
(2)	0.66	0.71	0.72	0.70	0.61	0.57	0.74	1.02	1.15	0.97	0.77	0.89	1.11	1.00	0.78	0.72	13.11
5.1- 8.0	240	263	133	134	170	193	228	439	515	428	323	535	679	457	319	269	5330
(1)	1.47	1.61	0.85	0.82	1.04	1.18	1.40	2.69	3.16	2.62	1.98	3.28	4.16	2.80	1.96	1.65	32.67
(2)	0.59	0.65	0.34	0.33	0.42	0.47	0.56	1.08	1.27	1.05	0.79	1.32	1.67	1.12	0.78	0.66	13.10
8.1-10.9	65	63	11	14	16	23	40	152	139	119	137	200	209	102	86	73	1446
(1)	0.40	0.39	0.07	0.10	0.10	0.14	0.25	0.93	0.85	0.73	0.84	1.23	1.28	0.63	0.53	0.45	8.86
(2)	0.16	0.15	0.03	0.04	0.04	0.06	0.10	0.37	0.34	0.29	0.34	0.49	0.50	0.25	0.21	0.18	3.55
OVER 10.9	25	19	13	21	18	22	17	39	58	52	95	132	80	29	29	23	662
(1)	0.15	0.12	0.08	0.13	0.11	0.13	0.10	0.24	0.36	0.32	0.58	0.81	0.49	0.18	0.18	0.14	4.06
(2)	0.06	0.05	0.03	0.05	0.04	0.05	0.04	0.10	0.14	0.13	0.23	0.32	0.20	0.06	0.06	0.06	1.63
ALL SPEEDS	755	946	688	691	639	667	883	1345	1442	1276	1066	1425	1649	1181	935	825	16313
(1)	4.63	5.18	4.22	4.23	3.92	4.09	5.41	8.24	8.84	7.82	6.53	8.73	10.11	7.24	5.73	5.06	99.98
(2)	1.86	2.08	1.69	1.70	1.57	1.64	2.17	3.31	3.55	3.14	2.62	3.50	4.05	2.90	2.30	2.03	40.10

Note: (1)=PERCENT OF ALL GOOD OBS FOR THIS PAGE
(2)=PERCENT OF ALL GOOD OBS FOR THE PERIOD

16317 HRS ON THIS PAGE 4 HRS (0.0 PCT) LESS THAN 0.3 MPS (0.0 PCT OF ALL HRS)

TIME TO DETONATION

PROBABILITY OF DETONATION BETWEEN 410 AND 610 SECONDS AFTER ACCIDENT

EXP(-410/300) - EXP(-610/300) = 0.1241

MEAN TIME TO IGNITION = 300 SEC.

COMBINED PROBABILITY

PROBABILITY OF AN ACCIDENT IN SEGMENT 8 = 4.00×10^{-5}

PROBABILITY OF UNFAVORABLE WIND DIRECTION = .0079

PROBABILITY OF DETONATION GIVEN AN ACCIDENT = 0.0111

PROBABILITY OF DETONATION IN TIME INTERVAL = 0.1241

$(4 \times 10^{-5})(0.0079)(0.0111)(0.1241) = 4.35 \times 10^{-10}$

TOTAL PROBABILITY

$$P = P_r \times P(D/R) \times F \times \sum_{N=1}^{NP} \sum_{S=1}^{7} \sum_{V=1}^{6} \sum_{I=1}^{NT} \sum_{D=1}^{16} P_w(S,V,D) \times P_d(T_{I-1},T_I) \times L(N) \times d(S,V,D,I,N)$$

where:

P_r = probability of rupture per tank mile
$P(D/R)$ = probability of detonation (explosion) given a rupture
F = frequency of shipment of tanks carrying FCG, in shipments per year
$P_w(S,V,D)$ = probability that wind of stability class S, speed V, and direction D is blowing when detonation occurs
$P_d(T_{I-1},T_I)$ = probability that detonation occurs between times T_{I-1} and T_I, given that a rupture has occurred
$L(N)$ = length of railroad segment N, in miles
NP = number of railroad segments considered in analysis
NT = number of detonation time intervals
$d(S,V,D,I,N)$:
= 1 if overpressure exceeds the one psi criterion for S,V,D,I,N
= 0 if overpressure does not exceed the one psi criterion

CONTRIBUTION OF EACH RAILROAD SEGMENT TO TOTAL PROBABILITY

Duration: 1500 seconds
Mean Duration Time: 300 seconds

Segment Number	Contribution (%)
1	1.0
2	2.9
3	3.9
4	3.3
5	4.0
6	3.4
7	5.5
8	6.4
9	6.0
10	7.6
11	8.3
12	8.2
13	6.6
14	5.2
15	4.8
16	4.2
17	3.5
18	2.4
19	2.8
20	2.5
21	2.7
22	2.2
23	1.2
24	0.7
25	0.4
26	0.3
TOTAL	100.0 = 2.3×10^{-7} per year

MAXIMUM PROBABILITY OF EXCEEDING
1 PSI AT PLANT DUE TO TANK CAR
ACCIDENT

2.3×10^{-7} PER YEAR

Conservative Basis for CPS Explosive Hazards Analysis

- Methodology used in compliance with NUREG-0014.
- Most detonations that have occurred, happened at the point of gas release.

  Formation of vapor cloud which drifts towards plant with subsequent detonation considered.

  James "Codes and Statistics" for AAR

  81 Ignitions
  58% 0-50 ft.
  18% 50-100 ft.
  24% 100-300 ft.

- No credit taken for destabilizing effect of Lake Clinton.

  ▶ Additional diffusion in the vertical over lake.

- All Tank cars assumed to carry propane with contents of 160,000 lbs. of fuel (80 tons). E.G. LPG cars weighed 70 tons avg.

Conservative Basis for CPS Explosive Hazards Analysis

- Analysis assumed that as liquefied gas escaped, 100% flash vaporized.
  - ▶ NUREG/CR-0075 says only 1/3 would flash vaporize immediately, remainder staying as liquid droplets. This remainder would not contribute to explosive hazard.
- No rise of the plume due to buoyancy assumed.
- Equivalent weight of TNT taken as 240% of gas contained in car. R.G. 1.91 indicates 240% represents an upper bound for hydrocarbons.
- Tank car modifications. No credit taken for federally mandated safety features:
  1. Coupler restraints
  2. Tank head shields
  3. Thermal protection systems
  4. Safety relief valves

  ▶ At least factor of 2x reduction in accidents.

Conservative Basis for CPS Explosive Hazards Analysis

- Exceeding 1 PSI overpressure will not necessarily result in radioactivity release, much less in excess of 10CFR100.
- Maximum safe overpressure for CPS is 1.65 PSI, which is 1/2 the tornado wind design (3.3 PSI).

- CONCLUSIONS - EXPLOSIVE HAZARDS ANALYSIS

  - DETAILED STUDY PERFORMED
  - R.G. 1.91 CRITERIA APPLIED
  - NUREG-0014 METHODOLOGY UTILIZED
  - INDUSTRY RELEASE DATA APPLIED
  - CONSERVATISMS APPLIED
  - RESULTS ACCEPTABLE:
    - WORST CASE PROBABILITY = 2.3×10^{-7} PER YEAR (LESS THAN 10^{-6} R.G. 1.91 ACCEPTANCE CRITERIA).

CONCLUSIONS/CPS REGULATORY COMPLIANCE

- TOXIC HAZARDS ANALYSIS

	CAR-MILE BASIS	TON-MILE BASIS
ANHYDROUS AMMONIA	4.06×10^{-7}	4.86×10^{-7}
BROMINE	1.77×10^{-6}	8.50×10^{-7}
TOTAL TOXIC HAZARD	2.18×10^{-6}	1.34×10^{-6}

▶ PROBABILITIES ADJUSTED WITH APPLICATION OF QUANTIFIED CONSERVATISMS.....

-TANK CAR MODS. (2X REDUCTION)

-OPERATOR INCAPACITATION (10X REDUCTION)

I.E. CAR-MILE BASIS = 1.09×10^{-7}

TON-MILE BASIS = 6.7×10^{-8}

COMPLIES WITH STANDARD REVIEW PLAN (NUREG-0800) AND R.G. 1.78, I.E. $< 10^{-6}$.

Conclusions/CPS Regulatory Compliance

- Explosive Hazards Analysis
  - Worst-Case Probability = 2.3×10^{-7}

    Complies with R.G. 1.91 criteria, I.E. $< 10^{-6}$

- Issue of Transportation Accidents (SER Outstanding Issue #1) Adequately Addressed and No Plant Modifications Required.