

PPG INDUSTRIES
EXHIBIT H-5

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Subject to Protective Order
of 14th Judicial District Court
No. 91-1145

PPG Industries, Inc.
Industrial Chemical Division
Lake Charles, Louisiana

LR-2284

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The Reliability Study of the Lake Charles Plant "B-II" - EDC Plants 1 & 2

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RELIABILITY STUDY OF EDC PLANTS 1 & 2

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ABSTRACT

A detailed Reliability Study (Level III) and a Loss Prevention Review were made on EDC Plants 1 & 2. Fault trees were drawn and quantified to determine the frequency of occurrence of potential hazards encountered during the operation of the vaporizers and the reactors. The potential hazards, identified and studied, were the possibility of liquid chlorine entering the reactor, reactor overpressurization and the formation of an explosive mixture of chlorine and ethylene in the vent or the vapor space of the reactor. Flammable liquid spill fires were not in the scope of this study, since system integrity is assumed. Implementation of the proposed recommendations significantly reduces the frequency of occurrence of these potential hazards and enhances the reliability of EDC Plants 1 & 2.

INTRODUCTION

A Level III Reliability Study was made of the EDC Plants 1 & 2 as part of the continuing effort to study all of the units in Plants "B-I" and "B-II". This report will complete the study of Plant "B-II".

DISCUSSION

To become familiar with the EDC Plants 1 & 2, the operating manual and the P & I drawings were studied. Discussions with operations personnel along with plant tours provided operating knowledge of the plants. Cause-Consequence sheets were then developed with the aid of an operations representative for each piece of equipment in the plant. This indicated the areas of potential hazard which were the chlorine vaporizers and the EDC Reactors 1, 2 & 3. Fault trees were developed for these areas assuming system integrity (no pipe leaks, pump leaks, sample point leaks or failure due to corrosion). The remainder of the plant was assumed to be covered sufficiently by the Cause-Consequence sheets.

The fault trees were quantified using data from the ICI manual of failure rates by D. W. Heckle along with information gathered from previous studies, operations experience, and other published sources. Some of the failure rate data obtained was modified to fit the conditions applicable to the EDC Plants 1 & 2.

The hazards or top events covered by the fault trees are:

1. The possibility of liquid chlorine entering the reactor, and a run away reaction.
2. The formation of an explosive mixture of chlorine and ethylene in the vent.
3. Reactor overpressurization from feed or pressure control valve failures.
4. The formation of an explosive mixture of chlorine and ethylene in the vapor space of the reactor.

The frequency of occurrence for each hazard, associated with the plant in its current condition, was calculated assuming a six-month proof-test interval. This assumption was based on the fact that the proof-test program is well established and accepted. If the hazard frequency was too high, recommendations were incorporated into the fault trees. The fault trees were then re-calculated to see how effective the recommendations were at reducing the hazard frequency. If the hazards involve possible releases of either flammable or toxic materials the amount and the frequency of these releases were evaluated to determine if the calculation of the severity of these releases was required. The ICI computer program TOXIDISP was used to calculate the severity where necessary.

The potential release of Cl_2 from the vaporizers was not evaluated due to the pending project to modify vaporizer shutdown systems. The possibility of Cl_2 releases from the reactor, due to the failure of the Cl_2 flow control valve, was remote and did

not warrant further evaluation. The potential problems associated with excessive oxygen entering with the chlorine were not addressed because they are included in the DSA Gas to EDC Reliability Study.

Flammable releases were handled according to C. R. West's paper "Fire/Explosion Methodology". Under the guidelines in this paper most of the potential releases did not meet the criteria to form a vapor cloud. Those releases, caused by still overpressurization, that did meet this criteria were comparable to releases that were evaluated by TOXIDISP in the OHC II study and found to present minimal cloud hazard according to this methodology. EDC release from the reactor due to overpressurization was studied using the TOXIDISP computer program to determine the probability that a vapor cloud of sufficient concentration (1/2 the lower explosive limit) to pose a hazard would encounter a known ignition source. The computer program revealed that the cloud was well below the concentration to be considered hazardous (1/2 LEL) by the time it reached the ground. Therefore there is no hazard from the release of EDC from the reactors, strippers or stills other than a local fire hazard at the point of release.

A Loss Prevention Review was conducted to expand the scope of the Reliability Study. The additional examination of the process with respect to codes of practice, fire protection and other items not normally embraced by a Reliability Study should strengthen the overall process safety posture.

The Loss Prevention Review for EDC Plants 1 & 2 was conducted using the General Office Loss Prevention Manual. With the aid of an operations representative and other informed personnel it was determined that EDC complied with most of the requirements. Several points of contention are currently on the Loss Prevention Job (LPJ) List and there are several control valve failure position changes that are under consideration.

The LPJ list was studied to determine the status of jobs that the ORC or previous safety studies had requested but had not yet been completed. This review found that the jobs on the LPJ list are receiving very little emphasis although many of the jobs are on hold waiting for either C₂H₄ analyzers to be installed, the vaporizer shutdown system project to be completed or modernization of the diaphragm cell chlorine plant. The remaining jobs warrant discussion by the ORC.

The Reliability Study of the EDC tank vent lines requested by LPJ-929 was incorporated into this study. This covered the equipment to process the EDC vents to the incinerator from the converted Butadiene Tank and the EDC Day Tank. This system was similar to the system covered by a reliability study in P-71 on the million gallon tank among others. Therefore the LPJ-929 system was studied qualitatively and appeared to be reliable which was substantiated by the fault trees and calculations done on P-71.

RESULTS

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The results presented in Table I show the frequency of occurrence of hazards associated with the operation of the vaporizers and reactors. Each hazard frequency was calculated to show what could be expected by the plant in its present condition and if modifications were recommended.

The vaporizers, in their current condition, appear vulnerable to allowing liquid chlorine to enter the reactor. Several layers of modifications were recommended with each layer increasing the reliability of safe chlorine vaporizer operations. The vaporizers, as presently equipped, could be expected to allow liquid chlorine into the reactor about once every 10 years. With the addition of a Low Temperature Alarm on the Cl_2 Surge Tank this frequency can be reduced by over a factor of 10 to once every 105 years. This modification plus Low Steam Pressure and Flow Alarms further reduces the frequency to once every 476 years. The installation of dual steam traps coupled with the above recommendations virtually eliminates the hazard down to once every 14,000 years.

The possibility of an explosive mixture of C_2H_4 and Cl_2 occurring in the vent header is about once every 1,000 years. This calculation was made assuming the C_2H_4 analyzers were incorporated into the shutdown system.

The frequency of occurrence of reactor overpressure releasing flammable or toxic gases to the atmosphere is about once every 28 years with the reactor system as is. The addition of a redundant pressure transmitter reduces this frequency by almost a factor of 10 to once every 257 years. This possible release when evaluated by the TOXIDISP computer program proved to be non-hazardous as far as a vapor cloud explosion is concerned because the amount of material released would be dispersed before it reached an ignition source.

The chance of a vapor phase reaction/explosion in the reactor is almost once every 1,000 years.

RECOMMENDATIONS

In order to reduce the hazard of frequencies to acceptable levels several additions should be made as well as maintaining high maintenance and operations standards. These include:

1. Improve chlorine vaporizer system by engineering:
 - A. Dual steam traps on each vaporizer with access for observation of condensate flow.
 - B. Low steam pressure and flow alarms on streams to vaporizers.
 - C. Low Cl_2 temperature alarm on the bottom of the surge tank.
2. Study chlorine vaporizers plant wide to develop a uniform standard for materials of construction, instrumentation, and operating practices.
3. Incorporate a standard vaporizer shutdown system.

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4. Improve EDC Reactor reliability by installing:
 - A. C_2H_4 analyzers on the vents.
 - B. Redundant pressure transmitter on each reactor (1, 2 & 3).
5. Restrict to a minimum the amount of time the reactor shutdown system is on by-pass.
6. Provide proper proof-testing at the intervals specified in Table II.
7. Revise and update EDC operating manual (LPJ-980).
8. Revise and update P & I drawings to accurately show what exists in the field.
9. Review the LPJ list to determine status of jobs requested and remove those of marginal impact. This will be done by the Operations Review Committee.

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8/18/82

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9/23/82

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TABLE I
HAZARD FREQUENCIES
(6 Month Proof Test Interval is Assumed)

<u>Fault Tree</u>	<u>Hazard (Top Event)</u>	<u>Occasions/Year</u>	<u>Years Between Occurrences</u>
1	Liquid Cl ₂ entering the reactor and leading to a runaway reaction.		
A.	Cl ₂ vaporizer system as is	.1035	9.66
B.	With low Cl ₂ surge tank temperature alarm	.0095	105
C.	With "B" and low steam pressure and flow alarms	.0021	476
D.	With "C" and dual steam traps w/observation	.00007	14,318
4	Formation of an explosive mixture of chlorine and ethylene in vent (C ₂ H ₄ analyzers assumed in operation)	.00099	1,008
7	Reactor over pressurization		
A.	Reactor system as is	.0361	27.7
B.	With redundant pressure transmitter	.0039	257
8	Formation of an explosive mixture of chlorine and ethylene in the vapor space of the reactor	.00099609	1,004

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TABLE II
PROOF TEST SCHEDULE

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<u>Vaporizers</u>	<u>Proof Test Interval</u>
Low Instrument Air Pressure Alarm	6 month
Steam Header Low Pressure Alarm	"
Vaporizer Outlet Low Temp Alarm	"
<u>Reactor #1</u>	
C ₂ H ₄ Low Pressure Alarm PT-2551	6 month
C ₂ H ₄ Low Flow Alarm FT-71	"
Cl ₂ High Flow Alarm FT-74	"
Low C ₂ H ₄ /Cl ₂ Ratio Alarm	"
Reactor Low Level Alarm LT-72	"
Reactor Low Level Alarm LT-72A	"
Reactor High/Low Pressure Alarm PT-1011	"
Reactor #1 Shutdown System	"
C ₂ H ₄ Analyzers	1 week
Reactor Recycle Pumps S/D Alarm	6 month
Cl ₂ High Pressure Alarm PT-56	"
<u>Reactor #2</u>	
C ₂ H ₄ High/Low Flow Alarm FT-51	6 month
Cl ₂ High/Low Flow Alarm FT-52	"
Low C ₂ H ₄ /Cl ₂ Ratio Alarm	"
Cl ₂ High Pressure Alarm PT-56	"
C ₂ H ₄ Analyzers	1 week
Reactor #2 Shutdown System	6 month
FCV-901 (To Scrubber)	"
FCV-920 Position Alarm	"
Reactor Low Level Alarm LT-72	"
Reactor Low Level Alarm LT-72A	"
<u>Reactor #3</u>	
C ₂ H ₄ High/Low Pressure Alarm PT-1005	6 month
C ₂ H ₄ High/Low Flow Alarm FT-1016	"
Cl ₂ High/Low Flow Alarm FT-1032	"
Low C ₂ H ₄ /Cl ₂ Ratio Alarm	"
Cl ₂ High Pressure Alarm PT-1028	"
C ₂ H ₄ Analyzers	1 week
Reactor #3 Shutdown System	6 month

TABLE II (Cont'd.)

PROOF TEST SCHEDULE (Cont'd.)

<u>Reactor #3 (Cont'd.)</u>	<u>Proof Test Interval</u>
FCV-900 (To Scrubber)	6 month
FCV-919 Position Alarm	"
Cooling Tower Water Pump S/D Alarm	"
Stripper Feed Pump S/D Alarm 1064	"
Reactor Low Level Alarm LT-1037	"
Reactor Low Level Alarm LT-1037A	"
Reactor High/Low Pressure Alarm PT-3004	"

All recommended instrumentation modifications that are accepted and installed should also be proof tested every 6 months.

All other instrumentation that is not involved in hazard frequency calculations should be proof tested according to Operations' schedule.

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APPENDIX

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EDC 1+2

VAPORIZER

SHEET 1A

6 mo P.T.

1/2

LESS ALARMS

INST AIR TO STEAM VALVES FAILS

.5 occ/yr

LOW INST AIR PRESSURE ALARM FAILS

D = .09

D = .5

H = .0106 (2)

N₀ = D - H = 4894OP FAILS

D = .4894 PF = .02

H = .0098

MAIN STEAM SUPPLY FAILS

.2 occ/yr

STEAM HEADER LOW PRESSURE ALARM FAILS

D = .2 @ .09

H = .0045 (1)

N₀ = D - H = 1955OP FAILS

D = .1955 PF = .02

H = .0039

MAIN STEAM PCV 141 (175 → 80#) FAILS CLOSED

.715 = @

VAPORIZER STEAM CHEST PCV 64 (80 → 5#) FAILS CLOSED

.3833 = @

OR GATE .3833 + .715 = 1.0983STEAM TRAP FAILS CLOSED

@ .3 f/y

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OR GATE

.0106 + .0098 + 1.0983 + .0045 + .0039 + .3 = 1.4271

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SHEET 14

6 m. P. T.

LESS ALARMS

VARIABLE OUTLET LOW TEMPERATURE ALARM FAIL

7:5

$$N_0 = D - H = 1.3506$$

OPERATOR FAILS TO RESPOND

$$P_f = .02$$

$$H = .027$$

$$.0765 + .027$$

≈ 1035

EVERY 9.66 YRS

W/ CL SURGE DRUM LOW TEMP ALARM

$$T = .5$$

no: D-H = .0969

OP FAILS

$$P_f = .03$$

H- 0029

0066 +.0039

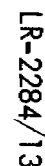
$$= .0095$$

EVERY 105 yrs

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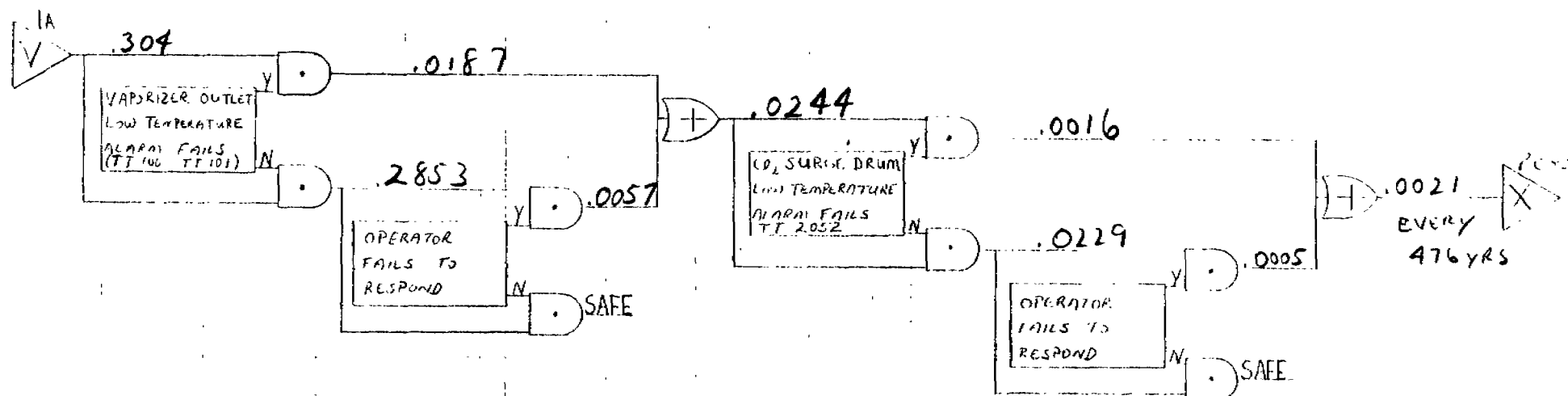
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1. $\mathbb{Z}[\sqrt{2}]$ is a subring of $\mathbb{Q}[\sqrt{2}]$.
 2. $\mathbb{Z}[\sqrt{2}]$ is a local ring.
 3. $\mathbb{Z}[\sqrt{2}]$ is a PID.



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VAPRIZER
 1/12/84
 2-1-10



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EDC 1+2

VAPORIZER

SHEET 1A Gmo P.T.

INSTRUMENT AIR TO STEAM VALVES FAILS

.5 OCC/YR (PLANT A+C RELIABILITY STUDY)

LOW INSTRUMENT AIR PRESSURE ALARM FAILSTRANSMITTER $.3 \times \frac{1}{2} \times \frac{1}{3} = .05$ ALARM $\frac{.04}{.09}$ D = .5 $\Theta = .09$

H = .0106 (2)

No = D-H = .4894

OPERATOR FAILS TO RESPONDD = .4894 $P_r = .02$

H = .0098

OR GATE $.0098 + .0106 = .0204$

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MAIN STEAM SUPPLY FAILS

.2 OCC/YR (PLANT "C" CR RELIABILITY STUDY)

STEAM HEADER LOW PRESSURE ALARM FAILSD = .2 $\Theta = .09$ (PT + ALARM)

H = .0045 (1)

No = D-H = .1955

OPERATOR FAILS TO RESPONDD = .1955 $P_r = .02$

H = .0039

OR GATE $.0045 + .0039 = .0084$

EOC 1+2

VAPORIZER

SHEET 1A Gms P.T

MAIN STEAM PCV 141 (175 → 80#) FAILS CLOSED

FIELD MOUNTED CONTROLLER	$.87 \times \frac{1}{2} = .435$	} SLOW + FAST FAILURES
PC VALVE	$.24 \times \frac{2}{3} = .16$	
POSITIONER	$.24 \times \frac{1}{2} = .12$	
	<u>.715</u>	

VAPORIZER STEAM CHEST PCV 64 (80 → 5#) FAILS CLOSED.

CONTROLLER	$.87 \times \frac{1}{2} \times \frac{1}{3} = .149$	} ONLY FAST FAILURES
PC VALVE	$.24 \times \frac{2}{3} \times \frac{1}{3} = .0533$	
POSITIONER	$.24 \times \frac{1}{2} \times \frac{1}{3} = .04$	
	<u>.3833</u>	

OR GATE

$$.715 + .3833 + .0204 + .0084 = 1.1271$$

LOW STEAM PRESSURE ALARM (PT-202) FAILS

$$D = 1.1271 \quad \theta = .09 \quad PT + ALARM$$

$$IT = .0221$$

$$NO = D - IT = 1.105$$

OPERATOR FAILS TO RESPOND

$$D = 1.105$$

% SEEING 1ST DEMAND :

$$\% \text{ " 2ND " } = .0137 / 1.1271 = .0122$$

$$P_{f1} = .02$$

$$P_{f2} = .04$$

$$D_1 = .9878(1.105) = 1.0915$$

$$D_2 = .0122(1.105) = .0134$$

$$H = D, P_{f1} + D_2 P_{f2}$$

$$= .0218 + .0005 =$$

$$= .0223$$

$$NO = D - H = 1.0827$$

OR GATE

$$.0223 + .0221 = .0444$$

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6m3 12 $\frac{1}{1}$

SL 012424

EDC 1+2

VAPORIZER

SHEET 1B

6m. P.T.

VAPORIZER OUTLET LOW TEMP ALARM FAILS (TT100 - 101)

$$\begin{array}{rcl}
 D = .304 & \Theta = .255 & TT = .125 \\
 & & TE = .09 \\
 & & \text{ALARM} = .04 \\
 & & \hline
 & & .255
 \end{array}
 \quad T = .5$$

$$H = .0187$$

$$N_0 = D - H = .2853$$

OPERATOR FAILS TO RESPOND

$$D = .2853 \quad P_f = .02$$

$$H = .0057$$

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OR GATE

$$.0057 + .0187 = .0244$$

CL₂ SURGE DRUM LOW TEMP ALARM FAILS TT 2052

$$D = .0244 \quad \Theta = .255 \quad T = .5$$

$$H = .0016$$

$$N_0 = D - H = .0229$$

OPERATOR FAILS TO RESPOND

$$D = .0229$$

$$\begin{array}{lcl}
 D_1 = (.0187 / .0244) (.0229) = .0175 & P_{f1} = .02 \\
 D_2 = (.0057 / .0244) (.0229) = .0054 & P_{f2} = .04
 \end{array}$$

$$H = D_1 P_{f1} + D_2 P_{f2}$$

$$= .0003 + .0002$$

$$= .0005$$

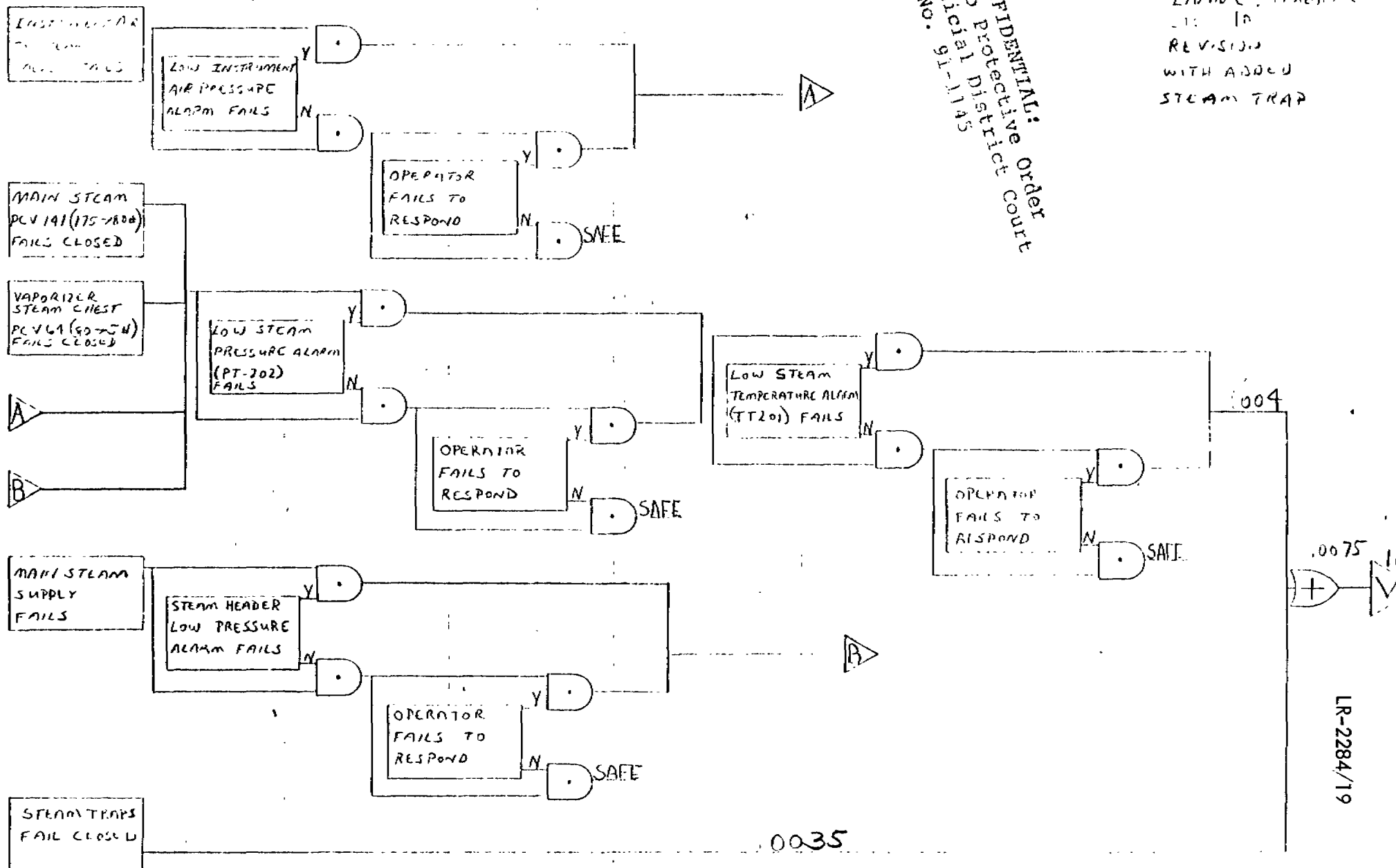
$$\text{OR GATE} \quad .0005 + .0016 = .0021$$

LIQUID CL₂ TO
VAPORIZER EVERY
476 YRS.

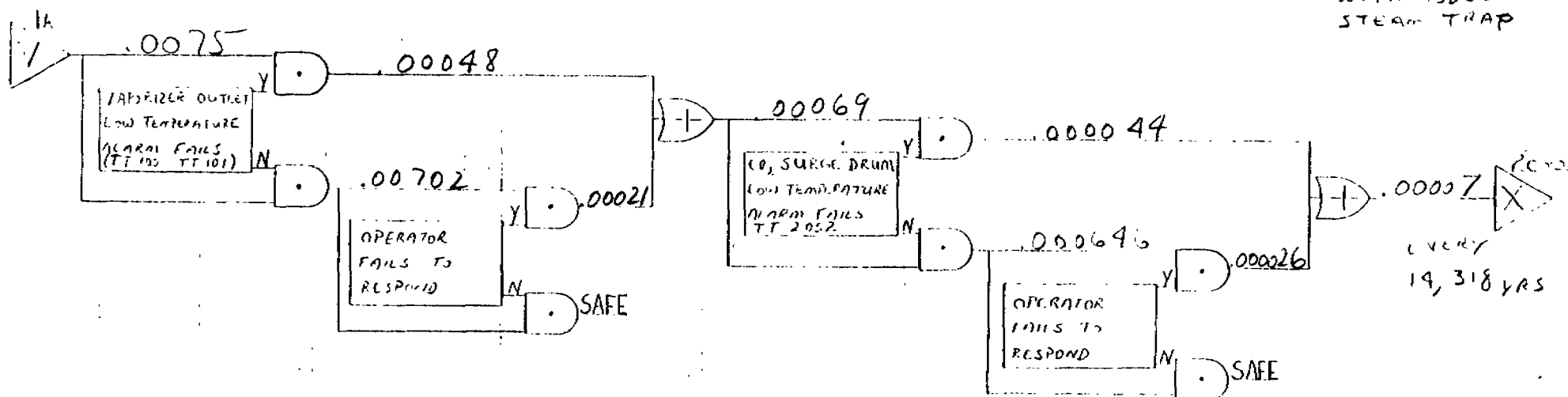
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IMPROVED
 LINDO C. TO REPAIR
 L11-1A
 REVISION
 WITH ADDED
 STEAM TRAP



14,318 yrs



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LUC 1+2

VAPORIZER

SHEET 1A+1B STEAM TRAP

REVISION ADDITION

STEAM TRAPS FAILADD 1 STEAM TRAP IN PARALLEL
WITH A SYSTEM FOR OPERATOR
OBSERVANCE. INSTALL- $\Theta = .24\%$ ICI-HECKLE
FOR POWER PLANTSCONDENSATE DRAIN SO DISCHARGE
IS VISIBLE. ASSUME THAT $\Theta = .34\%$ INCREASED FOR
CHEMICAL PLANT1 WEEK WOULD BE MAXIMUM
TIME THAT THE FIRST
TRAP FAILURE WOULD GO $f_1 = f_2 = .3 \quad t_1 = t_2 = 1/52 (\text{week})$ UNNOTICED.

$$H = (.3)(.3)(1/52 + 1/52) = .0035$$

$$\text{OR GATE} \quad .0035 + .004 = .0075 \quad \nabla^{1B}$$

1B RE

VAPORIZER OUTLET LOW TEMPERATURE ALARM FAILS (TT 100-101)

$$D = .0075 \quad \Theta = .255 \quad T = .5$$

$$H = .00048(1) \quad N_0 = .00702$$

OPERATOR FAILS TO RESPOND

$$D = .00702 \quad Pf = .03 \quad \text{SINCE PART OF DEMAND IS}$$

DUE TO PREVIOUS OPERATOR FAILURE

$$H = .00021$$

CL₂ SURGE DRAIN LOW TEMP ALARM FAILS (TT 2052)

$$D = .00069 \quad \Theta = .255 \quad T = .5$$

$$H = .000044 \quad N_0 = .000646$$

OPERATOR FAILS TO RESPOND

$$D = .000646 \quad Pf = .04 \quad \text{ASSUMING ALL DEMAND IS}$$

SEEING SECOND OPERATOR FAILURE

$$H = .000026$$

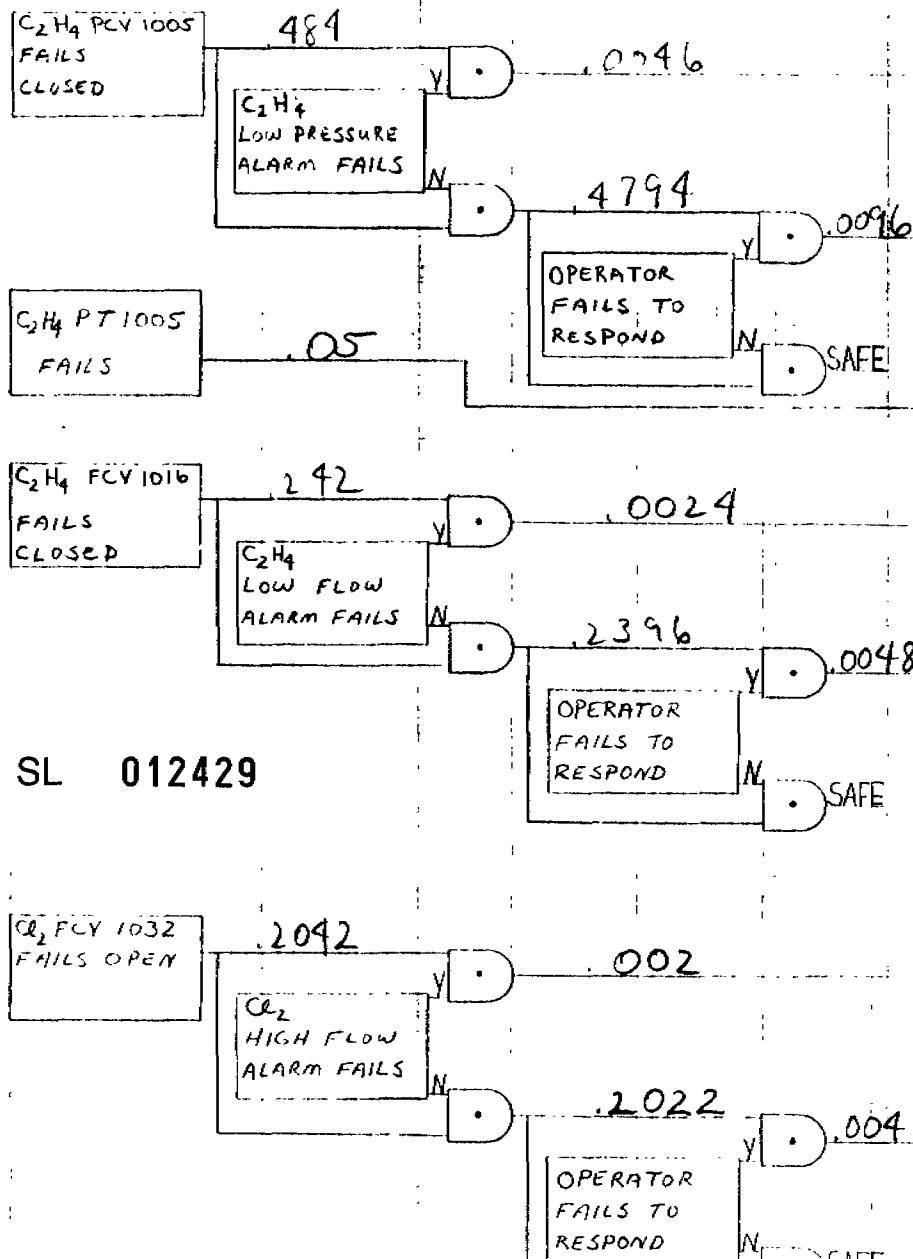
$$\text{OR GATE} \quad .000044 + .000026 = .00007$$

LIQUID CL₂
TO REACTOREVERY
19,318 YRS

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22. 10/10/00
WAT 2284/22
5. 10/10/00

0774
LOW C₂H₄/L₂,
RATIO
DEVIATION

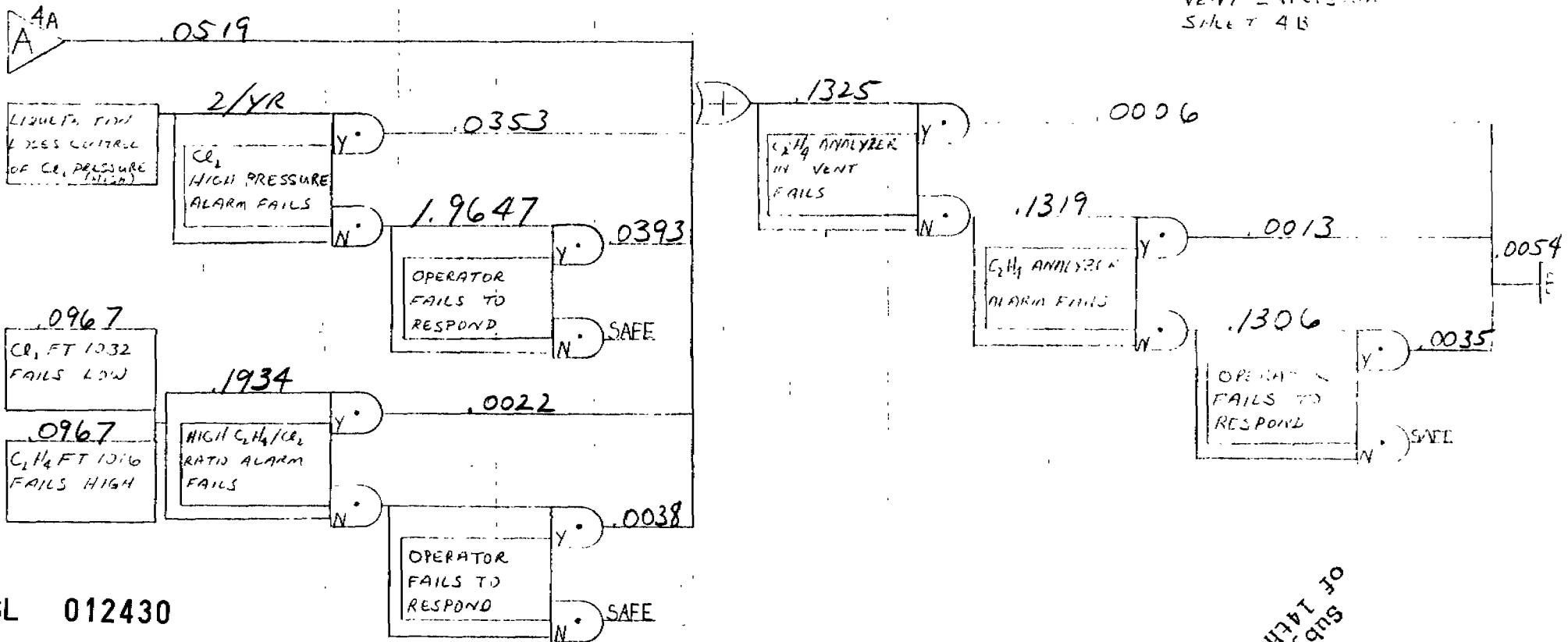
LARGE 0255 AC
SMALL B

0519

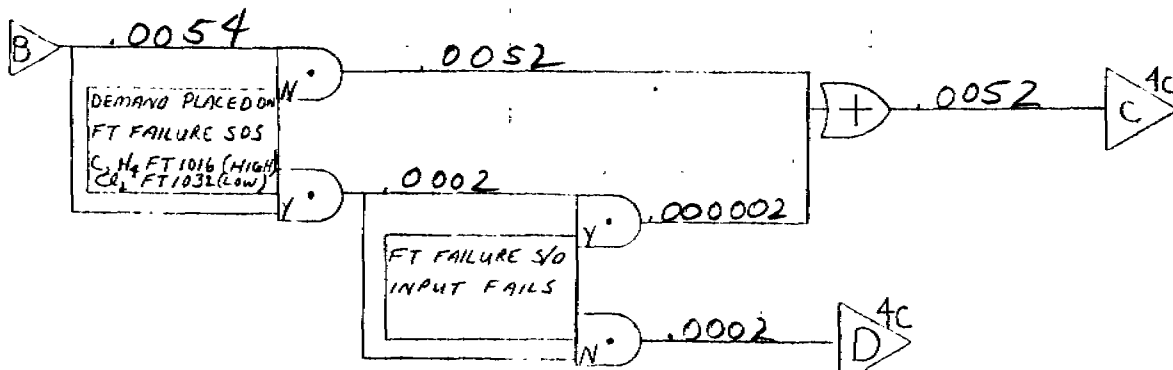
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EDC #3 REACTION
VENT EXPLOSION
SITE 7 4B

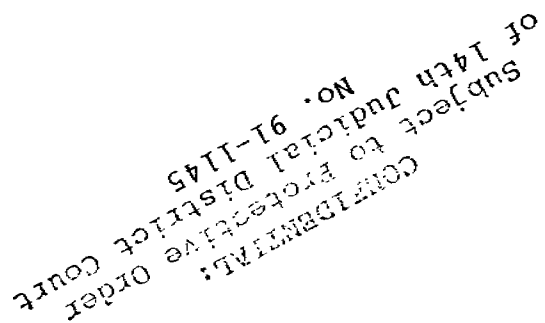


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EDC 1+2

REACTOR 3

SHEET 4 A 6 m 3 PROS-TEST

C₂H₄ PCV 1005 FAILS CLOSED

CONTROLLER $.29 \times \frac{1}{2} \times \frac{1}{3} = .0483$

SOLENOID $.068 \times \frac{2}{3} \times \frac{1}{3} = .015$

PY TRANSDUCER $.49 \times \frac{1}{2} \times \frac{1}{3} = .0817$

PV $.24 \times \frac{2}{3} \times \frac{1}{3} = .053$

POSITIONER $.24 \times \frac{1}{2} \times \frac{1}{3} = .04$

$.242$

$.484$

Θ

= Θ'

DOUBLE Θ TO
TAKE INTO
ACCOUNT ADDITIONAL
PCV'S ON C₂H₄
SUPPLY SYSTEM
(Θ')

C₂H₄ LOW PRESSURE ALARM FAILS

D = .484 Θ = .04 T = .5

H = .0046(2)

N₀ = D - H = .4794

OPERATOR FAILS TO RESPOND

D = .4794 P_r = .02 f₁ = .1 f₂ = .1 f₃ = .1 F₄ = 2

H = .4794(.02) = .0096

C₂H₄ PT 1005 FAILS

Θ = .3 × $\frac{1}{2} \times \frac{1}{3} = .05$

C₂H₄ FCV 1016 FAILS CLOSED

Θ = .242 SAME AS PCV 1005

C₂H₄ LOW FLOW ALARM FAILS

D = .242 Θ = .04

H = .0024(1)

N₀ = D - H = .2396

OPERATOR FAILS TO RESPOND

D = .2396 P_r = .02

H = .0048

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EDC 1+2 REACTOR 3 SHEET 4A 6m P.T.

4B

CL FCV 1032 FAILS OPEN

CONTROLLER	.29	$\times \frac{1}{2} \times \frac{1}{3}$	= .0483
SOLENOID	.062	$\times \frac{1}{2} \times \frac{1}{3}$	= .0075
TRANSDUCER FY	.49	$\times \frac{1}{2} \times \frac{1}{3}$	= .0817
FV	.24	$\times \frac{1}{3} \times \frac{1}{3}$	= .0267
POSIT SNUK	.24	$\times \frac{1}{2} \times \frac{1}{3}$	= .04

.2042 = 3

CL HIGH FLOW ALARM FAILS

D = 2042 0 04 T = .5

H = .002) No D-H = 2022

OPERATOR FAILS TO RESPOND

D = 2022 25 = 02

H = .004

OR GATE

.0046 + .0096 + .05 + .0024 + .0048 + .002 + .004 = .0774

LOW C_2H_4/Cl_2 RATIO DEVIATION

.667 SMALL

= .0519

.333 LARGE

= .0255

LIQUEFACTION LUSES CONTROL OF Cl_2 PRESSURE (HIGH)

1/YR THAT AFFECT EDC (BASED ON DISCUSSION W/MARIO JAVES)

Cl_2 HIGH PRESSURE ALARM FAILS

SIGNAL NOT TRANSMITTED PT 1028

D = 2 0 .05 T = .5

H = .0197(2)

No = D-H = 1.9803

ALARM FAILS

D = 1.9803 0 .04

H = .0156

No = D-H = 1.9647

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SL 012433

EDC 1+2 REACTOR 3 SHEET 4B 6mo P.T.OPERATOR FAILS TO RESPOND

$$D = 1.9647 \quad P_c = .02$$

$$H = .0393$$

C₂H₄ FT 1032 FAILS LOW

$$.58 \times \frac{1}{2} \times \frac{1}{3} = .0967$$

C₂H₄ FT 1016 FAILS HIGH

$$.58 \times \frac{1}{2} \times \frac{1}{3} = .0967$$

OR GATE

$$.0967 + .0967 = .1934$$

HIGH C₂H₄/C₂ RATIO ALARM FAILS

$$D = .1934 \quad \theta = .0452 \quad T = .5$$

$$H = .0022 (1)$$

$$N_0 = D - H = .1912$$

OPERATOR FAILS TO RESPOND

$$D = .1912 \quad P_c = .02$$

$$H = .0038$$

OR GATE

$$.0519 + .0353 + .0393 + .0022 + .0038 = .1325$$

C₂H₄ ANALYZER INVENT FAILS 1 out of 2

$$D = .1325 \quad \theta = .6 \quad T = .019$$

$$H = .0006$$

$$N_0 = D - H = .1319$$

C₂H₄ ANALYZER ALARM FAILS

$$D = .1319 \quad \theta = .04 \quad T = .5$$

$$H = .0013$$

$$N_0 = D - H = .1306$$

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ED 144 REACTOR 3 SHEET 4B Gms P.T. 4C

OPERATOR FAILS TO RESPOND

$$D = .1306$$

$$P_{F1} = .02$$

$$P_{F2} = .04$$

$$D_1 = .0261$$

$$D_2 = .0425$$

$$H = D_1 P_{F1} + D_2 P_{F2}$$

$$= .0018 + .0017 = .0035$$

$$\text{OR GATE } .0035 + .0013 + .0006 = .0054$$

DEMANDS PLACED ON FT FAILURE S/Ds C_2H_4 (low) Cl_2 (low)

$$\frac{.0022 + .0038}{.1325} [.0054] = .0002$$

$$N_3 = .0052$$

FT FAILURE S/D INPUT FAILS

$$D = .0002$$

$$\Theta = .0452$$

$$T = .5$$

LOW C_2H_4/Cl_2 RATIO ALARM FAILS

$$D = .0255$$

$$\Theta = .0452$$

$$T = .5$$

$$H = .0003(1)$$

$$N_0 = D - H = .0252$$

OPERATOR FAILS TO RESPOND

$$D = .0252$$

$$P_{F1} = .02 \quad D_1 =$$

$$P_{F2} = .04 \quad D_2 =$$

$$= .0192$$

$$H = D_1 P_{F1} + D_2 P_{F2}$$

$$= .0184 / .0774 [.0252] = .006$$

$$= .0004 + .0002 = .0006$$

LOW C_2H_4/Cl_2 RATIO S/D INPUT FAILS

$$D = .0009$$

$$\Theta = .0452$$

$$T = .5$$

$$H = .00001$$

$$N_0 = D - H = .0009$$

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EDC 1 + 2 REACTOR 3 SHEET 4C 6m P.T.

C₂H₄ ANALYZER IN VENT FAILS

PREVIOUS FAILURE IS FACTORED OUT

$$D = .00521 \quad \text{FACTOR} \frac{.0053}{.0054} = 11\% \text{ FAILED}$$

$$H = .00521(.1) \\ = .0006$$

ALL OTHER DEMANDS FIND

THE ANALYZER WORKING

$$N_0 = D + H = .0046$$

C₂H₄ ANALYZER S/D INPUT FAILS

$$D = .0009 \quad \Theta = .0452 \quad T = .5$$

$$H = .0001 \quad N_0 = D - H = .0045$$

OR GATE

$$.0002 + .0009 + .00455 = .00565$$

S/D SYSTEM FAILS

$$D = .00565 \quad \text{FDT} = .05 \quad \text{SOS BY PASSED} \quad 2-3 \text{ TIMES/WH}$$

$$H = .00565(.05)$$

2-3 HRS EACH TIME
(TALKS W/ MARIO JAMES
MIKE GUIDRY)

$$F = .00028 \quad N_0 = D - H = .00537$$

S/D INPUT FAILS (PLC)

$$D = .00537 \quad \Theta = .0452 \quad T = .5$$

$$H = .00006 \quad N_0 = D - H = .00531$$

CL₂ VALVE FAILS TO CLOSE $\Theta = .073$

$$D = .00531$$

$$H = .000097$$

INCINERATOR VALVE FCV 919 FAILS TO CLOSE

$$D = .000097 \quad \Theta = \text{VALVE} = .29 \times \frac{1}{2} \times \frac{1}{3} = .027$$

$$\text{POSITIONER} = .29 \times \frac{1}{2} \times \frac{1}{3} = .04$$

$$\text{SOLENOID} = .063 \times \frac{1}{2} \times \frac{1}{3} = .021$$

$$\text{SWITCH} = .043 \times \frac{1}{2} \times \frac{1}{3} = .014$$

$$H/T = .0000024 + .00006 + .00028 \quad .102 = \Theta$$

$$= .00034$$

$$\text{OR GATE} \quad .00034 + .00065 = .00099$$

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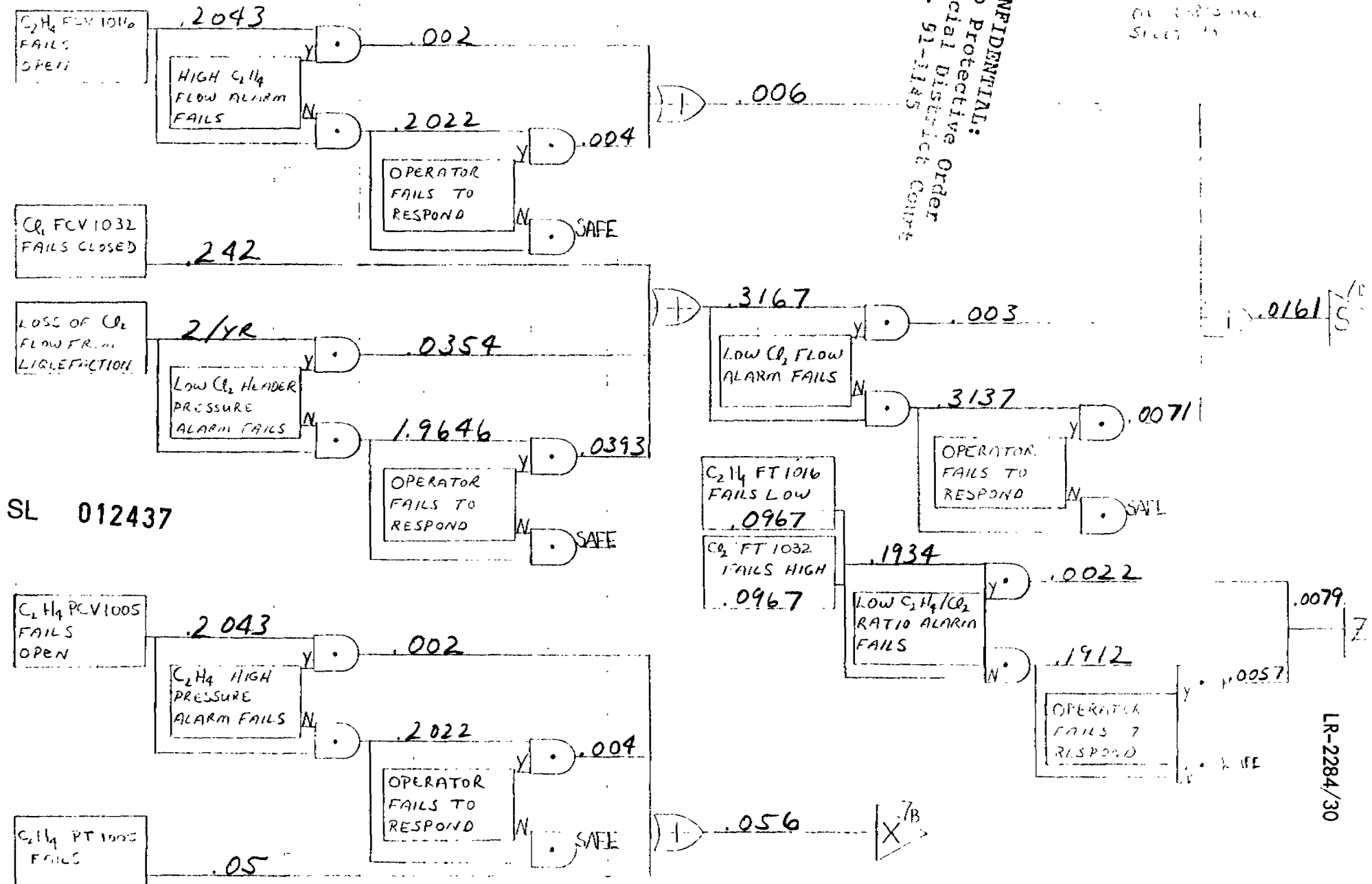
SL 012436

FROM R.E. HANDBOOK
TABLE 4 FAILURE RATES
DID NOT ELIMINATE SLOW
FAILURES SINCE S/D FEATS
COULD FAIL SLOWLY

EXPLOSIVE MIXTURE
IN VENT (EXCESS CL₂)
ONCE EVERY 1008 YRS.

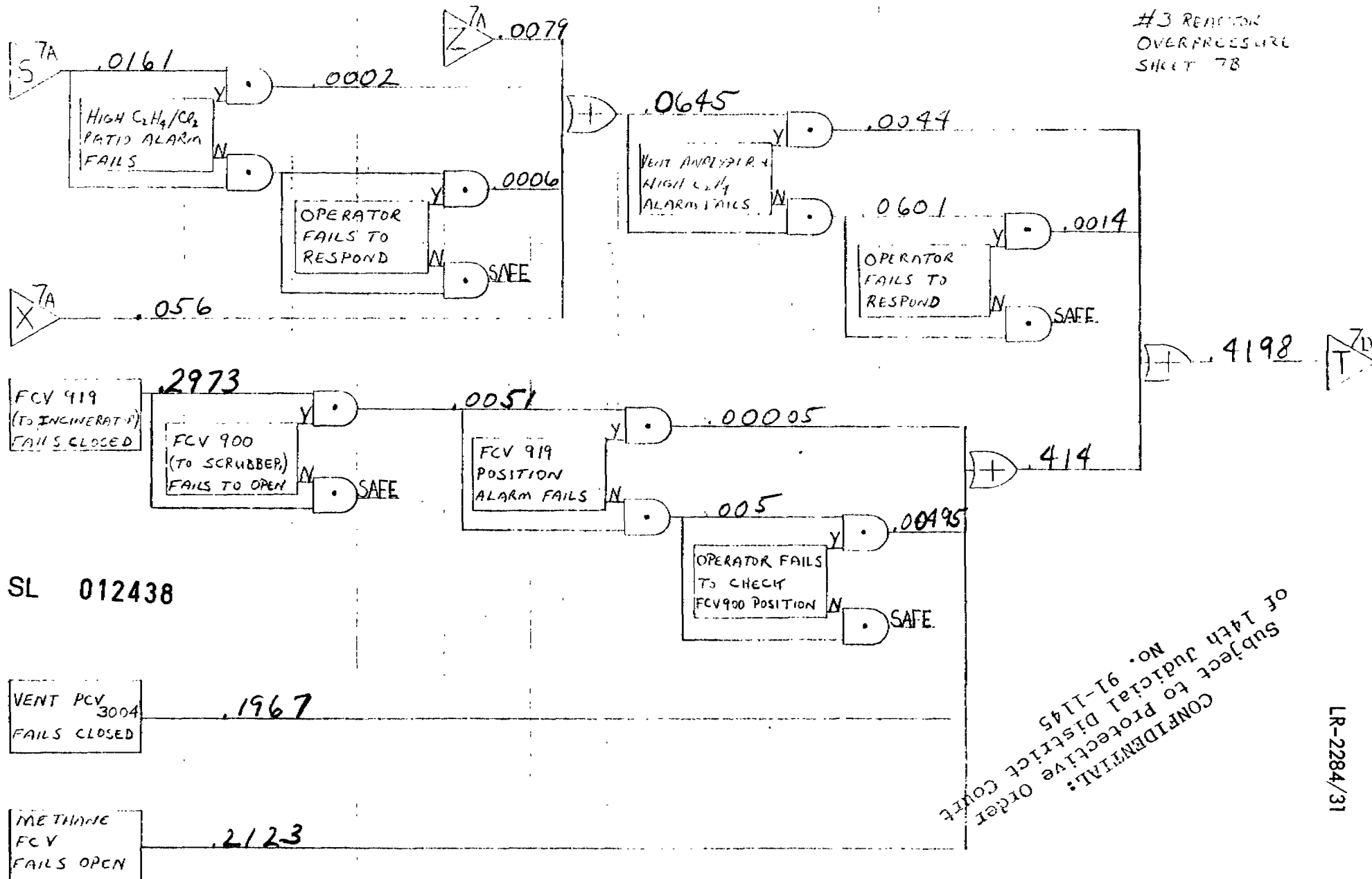
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H.L. REEDER
 CIVIL ENGINEER
 SHELTON, ID



SL 012437

#3 REACTOR
OVERPRESSURE
SHEET 7B

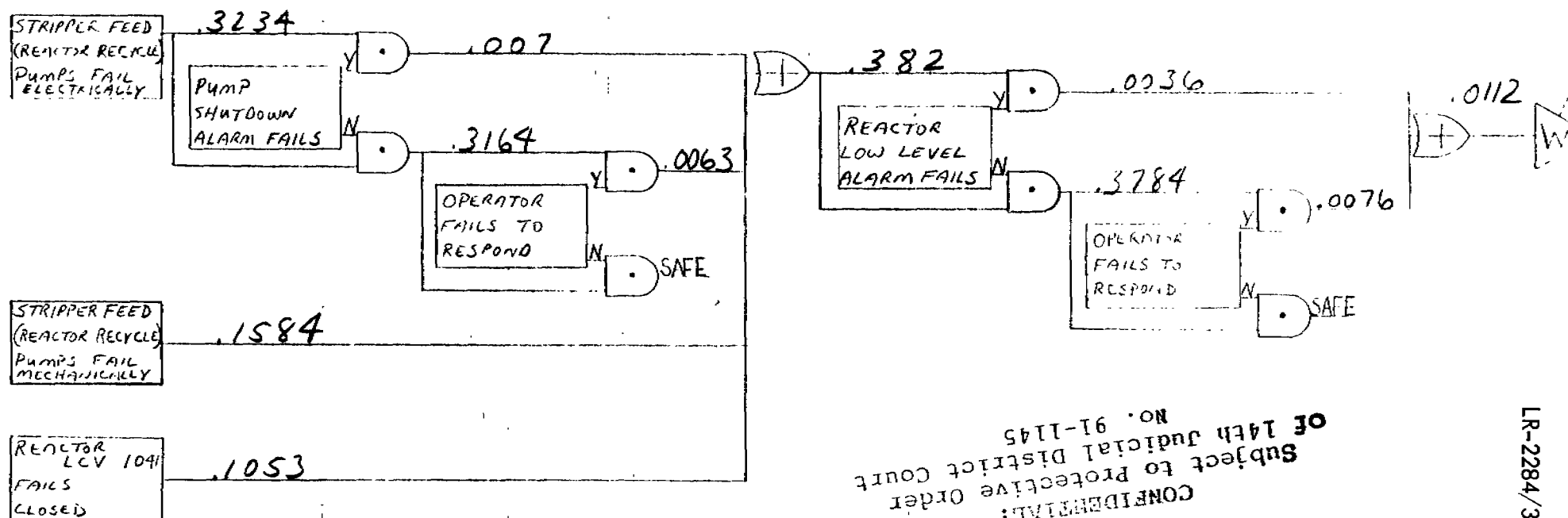
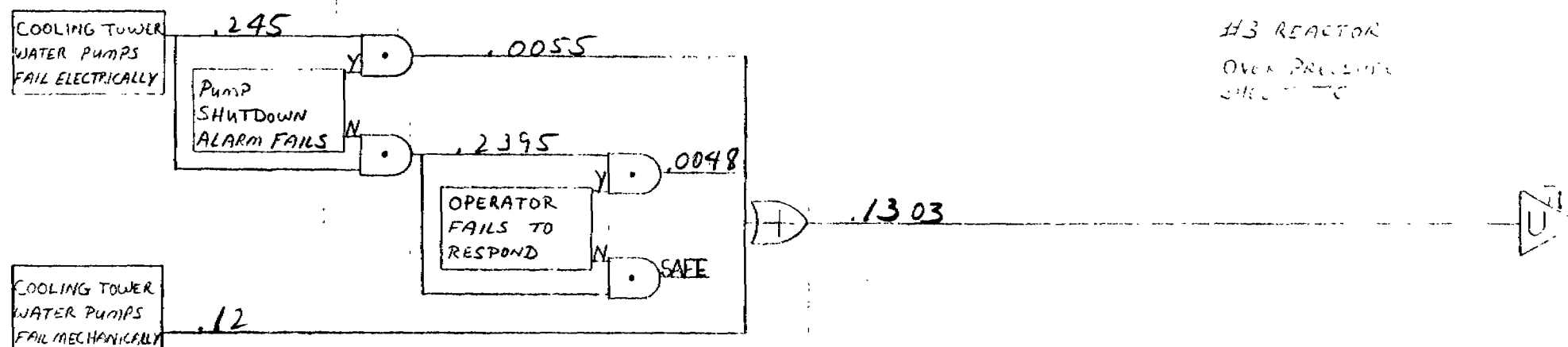


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LR-2284/31

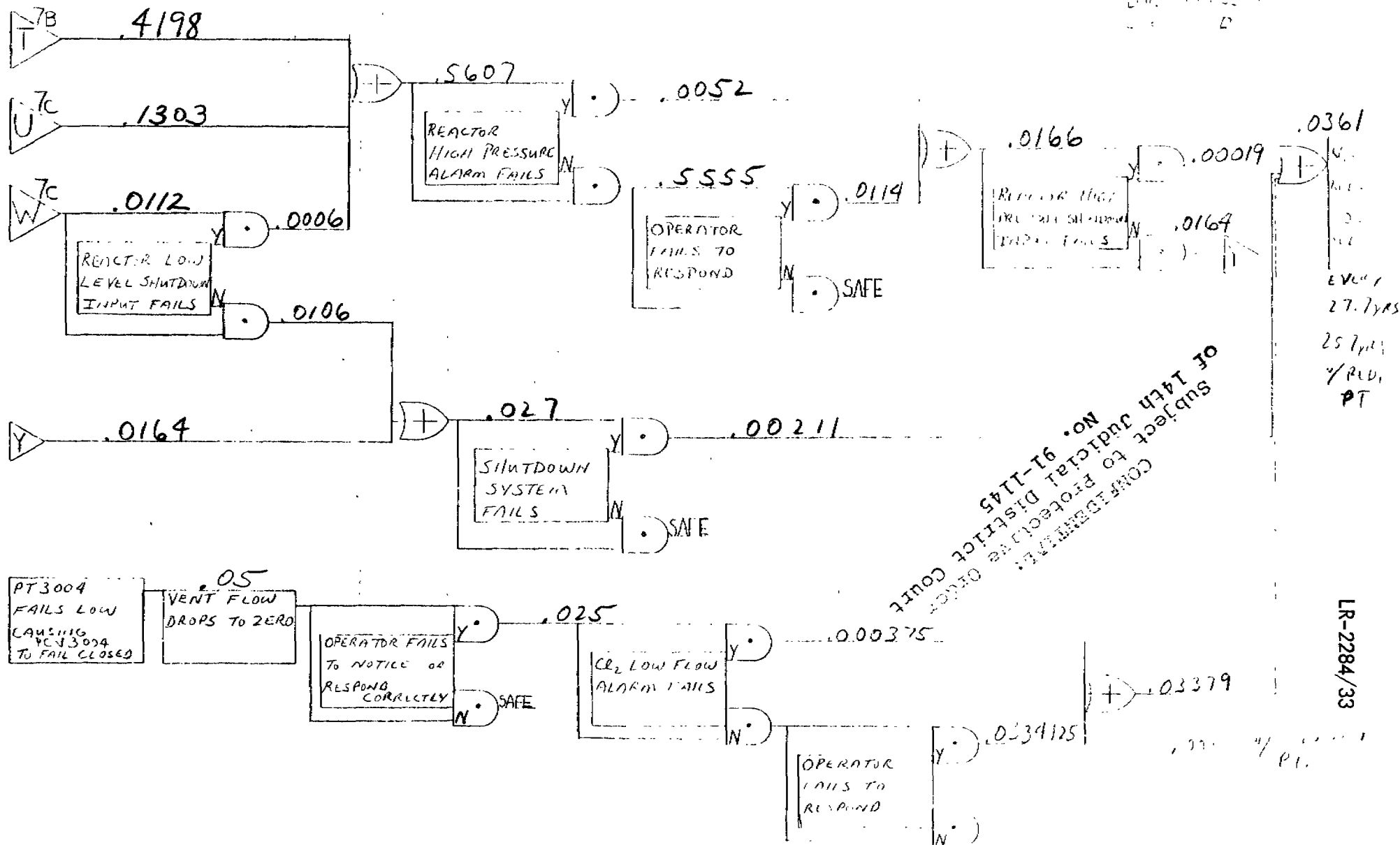
SL 012439



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LR-2284/32

SL 012440



CONTROLLER	$.29 \times \frac{1}{2} \times \frac{1}{3} = .048$
SOLENOID	$.038 \times \frac{1}{3} \times \frac{1}{3} = .0076$
FY TRANSDUCER	$.47 \times \frac{1}{2} \times \frac{1}{3} = .0817$
FV	$.24 \times \frac{1}{3} \times \frac{1}{3} = .027$
POSIT ORIENT	$.24 \times \frac{1}{2} \times \frac{1}{3} = .04$
	$.2043 : \odot$

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$D = .2043$ $\Theta = .04$ $T = .5$
 $H = .002$ $N_0 = 2 - 1 = .2022$

D- 2022 74 - 02
H- 0004

$$.504 + .002 = .506$$

CONTROLLER	$.29 \times \frac{1}{2} \times \frac{1}{3} =$	.0983
SOLENOID	$.068 \times \frac{1}{3} \times \frac{1}{3} =$	.015
TRANSDUCER FY	$.49 \times \frac{1}{2} \times \frac{1}{3} =$	.0817
FY	$.24 \times \frac{1}{3} \times \frac{1}{3} =$	.053
POSITIONER	$.24 \times \frac{1}{2} \times \frac{1}{3} =$	.04
		.242

SL 012441

$$D = 2/yr$$

$D = 2$ $\Theta = .05 = 3 \times \frac{1}{2} \times \frac{1}{3}$ TRANSMITTER $T = .5$
ALARM
 $H = .0354$ (2) $N_0 = D - H = 1.9646$

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OPERATOR FAILS TO RESPOND

$$D = .9646 \quad P_c = .02$$

$$H = .0393$$

OR GATE $.242 + .0354 + .0393 = .3167$

LOW Cl_2 FLOW ALARM FAILS

$$D = .3167 \quad \Theta = .04 \quad T = .5$$

$$H = .003 \quad N_0 = D - H = .3137$$

OPERATOR FAILS TO RESPOND

$$D = .3137 \quad D_1: \text{Demand signal 1st alarm} \quad .2748$$

$$D_2: \text{2nd alarm} \quad .0393 / .3167 (.3137) = .0389$$

$$P_{c1} = .02 \quad P_{c2} = .04$$

$$H = D_1 P_{c1} + D_2 P_{c2}$$

$$= .2748(.02) + .0389(.04)$$

$$= .0055 + .0016 = .0071$$

OR GATE

$$.0071 + .003 + .006 = .0161$$

$\triangle 5^{7B}$

C_2H_4 PCV 1005 FAILS OPEN

$$\Theta = .2043 \text{ same as FCV 1016 } (C_2H_4)$$

C_2H_4 HIGH PRESSURE ALARM FAILS

$$D = .2043 \quad \Theta = .04 \quad T = .5$$

$$H = .002 \quad N_0 = D - H = .2022$$

SAFETY SYSTEMS GROUP
DAVID L. SHARP, 001 786 77
44 44 44 44 44 44 44 44



EDC 1+2

REACTION 3

Sheet 7A Gms D.T.

OPERATOR FAILS TO RESPOND

$$D = .2022 \quad P_4 = .01$$

$$H = .004$$

C₂H₄ FT 1001 FAILS

$$\Rightarrow .58 \times \frac{1}{2} \times \frac{1}{3} = .0967$$

$$\text{OR GATE} \quad .05 + .004 + .002 = .056$$

X 7B

C₂H₄ FT 1016 FAILS LOW

$$.58 \times \frac{1}{2} \times \frac{1}{3} = .0967$$

CL₂ FT 1032 FAILS HIGH

$$.58 \times \frac{1}{2} \times \frac{1}{3} = .0967$$

OR GATE

$$.0967 + .0967 = .1934$$

LOW C₂H₄/CL₂ RATIO ALARM FAILS

$$D = .1934 \quad \theta = .0452 \quad T = .5$$

$$H = .0022 (1)$$

$$N_0 = D - H = .1912$$

OPERATOR FAILS TO RESPOND

$$D = .1912 \quad D = .03 \quad (\text{SINCE IT WILL ACTUALLY CAUSE HIGH RATIO})$$

$$H = .0057$$

OR GATE

$$.0022 + .0057 = .0079$$

X 7B

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41 381 3 SQUARE
42 382 100 SQUARE
43 389 376 SQUARE



EDC 1+2

REACTOR 3

SHEET 7B 6mo P.T.

4

HIGH C_2H_4/Cl_2 RATIO ALARM FAILS

$D = .0161$

$\theta = .0452$

$T = .5$

$H = .0002$

$N_0 = D - H = .0159$

OPERATOR FAILS TO RESPOND

$D = .0159$

$P_{F1} = .02$

$D_1 = \left[(.002 + .003) / .0161 \right] .0159 = .0049$

$P_{F2} = .04$

$D_2 = \left[(.0055 + .004) / .0161 \right] .0159 = .0074$

$P_{F3} = .08$

$D_3 = \left[.0046 / .0161 \right] .0159 = .0016$

$H = .0049(.02) + .0074(.04) + .0016(.08)$

$= .0001 + .0004 + .0001$

$= .0006$

OR GATE

$.0079 + .0006 + .056 = .0645$

VENT ANALYZER + HIGH C_2H_4 ALARM FAILS

$D = .0645$

$\theta = 6$

$T = 1/52$

ANALYZER FAILURE

$H = .0037$

$N_0 = D - H = .0608$

$D = .0608$

$\theta = .0452$

$T = .5$

ALARM FAILS

$H = .0007$

$N_0 = D - H = .0601$

$H_7 = .0037 + .0007 = .0044$

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REPLACES 2 SQUARE
 100 SHEETS 2 SQUARE
 42 301 511815
 42 301 511815
 42 301 511815



EDC 1+2 REACTOR 3 SITEET 7B 6m. P.T.

OPERATOR FAILS TO RESPOND

$$D = .0601 \quad P_{F1} = .02 D_1 \left[.0002 + .0022 + .052 / .0645 \right] .0601 = .0507$$

$$P_{F2} = .04 D_2 \left[.0057 + .004 / .0645 \right] .0601 = .0090$$

$$P_{F3} = .08 D_3 \left[.0006 / .0645 \right] .0601 = .0006$$

$$H = D_1 P_{F1} + D_2 P_{F2} + D_3 P_{F3}$$

$$= .0507(.02) + .009(.04) + .0006(.08)$$

$$= .001014 + .00036 + .000048$$

$$= .0014$$

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FCV 919 (TO INCINERATOR) FAILS CLOSED

$$\Theta = PT \quad .3 \times \frac{1}{2} \times \frac{1}{3} = .05$$

$$FT \quad .58 \times \frac{1}{2} \times \frac{1}{3} = .097$$

$$PS \quad .093 \times \frac{1}{2} \times \frac{1}{3} = .014$$

$$CONTROLLER \quad .29 \times \frac{1}{2} \times \frac{1}{3} = .0483$$

$$SOLENOID \quad .063 \times \frac{1}{2} \times \frac{1}{3} = .021$$

$$FCV \quad .24 \times \frac{1}{2} \times \frac{1}{3} = .027$$

$$POSITIONER \quad .24 \times \frac{1}{2} \times \frac{1}{3} = .04$$

$$.2973$$

FCV 900 (TO SCRUBBER) FAILS TO OPEN

$$D = .2973$$

$$\Theta = \text{SOLENOID} \quad .063 \times \frac{1}{2} \times \frac{1}{3} = .021$$

$$FCV \quad .24 \times \frac{1}{2} \times \frac{1}{3} = .027$$

$$POSITIONER \quad .24 \times \frac{1}{2} \times \frac{1}{3} = .04$$

$$.068$$

$$T = .5$$

$$H = .0051(1)$$

FCV 919 POSITION ALARM FAILS

$$D = .0051$$

$$\Theta = .04$$

$$T = .5$$

$$H = .00005$$

$$NO = D - H = .005$$

OPERATOR FAILS TO CHECK FCV 900 POSITION

OPERATOR WILL ASSUME SCRUBBER VALVE OPENS 99% OF TIME

$$D = .005$$

$$P_F = .99$$

$$H = .00495$$

SL 012445

LDC 1+2

REACTOR 3

SHEET 7B

Imp P.T.

7C

VENT PCV 3004 FAILS CLOSED

③ CONTROLLER	$.29 \times \frac{1}{2} \times \frac{1}{3} =$	.0483
TRANSDUCER	$.49 \times \frac{1}{2} \times \frac{1}{3} =$	.0817
PV	$.24 \times \frac{1}{3} \times \frac{1}{3} =$	.0267
POSITIONER	$.24 \times \frac{1}{2} \times \frac{1}{2} =$	.09
		<u>.1967</u>

METHANIL FCV FAILS OPEN

CONTROLLER	$.29 \times \frac{1}{2} \times \frac{1}{3} =$	.0483
TRANSMITTER (F)	$.58 \times \frac{1}{2} \times \frac{1}{3} =$	.097
VALVE	$.24 \times \frac{1}{3} \times \frac{1}{3} =$	.027
POSITIONER	$.24 \times \frac{1}{2} \times \frac{1}{3} =$	.04
		<u>.2123</u>

OR GATE $.2123 + .1967 + .00495 + .00005 = .414$ OR GATE $.0044 + .0014 + .414 = .4198$ COOLING TOWER WATER PUMPS FAIL ELECTRICALLY

2.4 MOTOR			
1.4 ELECTRICAL			
9.8	$\frac{9.8}{40} \left(\frac{1}{4} \right)$	WATER	.245 f/y

Pump S/D ALARM FAILS

D = .245	③ = .05	CONTACTS
	.04	ALARM
	.09	

 $H = .0055(1)$ $NO = D - H = .2395$ OPERATOR FAILS TO RESPOND $D = .2395$ $P_f = .02$ $H = .0048$

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REPLACES SHEETS 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 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497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000, 1001, 1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009, 1010, 1011, 1012, 1013, 1014, 1015, 1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1027, 1028, 1029, 1030, 1031, 1032, 1033, 1034, 1035, 1036, 1037, 1038, 1039, 1040, 1041, 1042, 1043, 1044, 1045, 1046, 1047, 1048, 1049, 1050, 1051, 1052, 1053, 1054, 1055, 1056, 1057, 1058, 1059, 1060, 1061, 1062, 1063, 1064, 1065, 1066, 1067, 1068, 1069, 1070, 1071, 1072, 1073, 1074, 1075, 1076, 1077, 1078, 1079, 1080, 1081, 1082, 1083, 1084, 1085, 1086, 1087, 1088, 1089, 1090, 1091, 1092, 1093, 1094, 1095, 1096, 1097, 1098, 1099, 1100, 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109, 1110, 1111, 1112, 1113, 1114, 1115, 1116, 1117, 1118, 1119, 1120, 1121, 1122, 1123, 1124, 1125, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 1135, 1136, 1137, 1138, 1139, 1140, 1141, 1142, 1143, 1144, 1145, 1146, 1147, 1148, 1149, 1150, 1151, 1152, 1153, 1154, 1155, 1156, 1157, 1158, 1159, 1160, 1161, 1162, 1163, 1164, 1165, 1166, 1167, 1168, 1169, 1170, 1171, 1172, 1173, 1174, 1175, 1176, 1177, 1178, 1179, 1180, 1181, 1182, 1183, 1184, 1185, 1186, 1187, 1188, 1189, 1190, 1191, 1192, 1193, 1194, 1195, 1196, 1197, 1198, 1199, 1200, 1201, 1202, 1203, 1204, 1205, 1206, 1207, 1208, 1209, 1210, 1211, 1212, 1213, 1214, 1215, 1216, 1217, 1218, 1219, 1220, 1221, 1222, 1223, 1224, 1225, 1226, 1227, 1228, 1229, 1230, 1231, 1232, 1233, 1234, 1235, 1236, 1237, 1238, 1239, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1249, 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257, 1258, 1259, 1260, 1261, 1262, 1263, 1264, 1265, 1266, 1267, 1268, 1269, 1270, 1271, 1272, 1273, 1274, 1275, 1276, 1277, 1278, 1279, 1280, 1281, 1282, 1283, 1284, 1285, 1286, 1287, 1288, 1289, 1290, 1291, 1292, 1293, 1294, 1295, 1296, 1297, 1298, 1299, 1300, 1301, 1302, 1303, 1304, 1305, 1306, 1307, 1308, 1309, 1310, 1311, 1312, 1313, 1314, 1315, 1316, 1317, 1318, 1319, 1320, 1321, 1322, 1323, 1324, 1325, 1326, 1327, 1328, 1329, 1330, 1331, 1332, 1333, 1334, 1335, 1336, 1337, 1338, 1339, 1340, 1341, 1342, 1343, 1344, 1345, 1346, 1347, 1348, 1349, 1350, 1351, 1352, 1353, 1354, 1355, 1356, 1357, 1358, 1359, 1360, 1361, 1362, 1363, 1364, 1365, 1366, 1367, 1368, 1369, 1370, 1371, 1372, 1373, 1374, 1375, 1376, 1377, 1378, 1379, 1380, 1381, 1382, 1383, 1384, 1385, 1386, 1387, 1388, 1389, 1390, 1391, 1392, 1393, 1394, 1395, 1396, 1397, 1398, 1399, 1400, 1401, 1402, 1403, 1404, 1405, 1406, 1407, 1408, 1409, 1410, 1411, 1412, 1413, 1414, 1415, 1416, 1417, 1418, 1419, 1420, 1421, 1422, 1423, 1424, 1425, 1426, 1427, 1428, 1429, 1430, 1431, 1432, 1433, 1434, 1435, 1436, 1437, 1438, 1439, 1440, 1441, 1442, 1443, 1444, 1445, 1446, 1447, 1448, 1449, 1450, 1451, 1452, 1453, 1454, 1455, 1456, 1457, 1458, 1459, 1460, 1461, 1462, 1463, 1464, 1465, 1466, 1467, 1468, 1469, 1470, 1471, 1472, 1473, 1474, 1475, 1476, 1477, 1478, 1479, 1480, 1481, 1482, 1483, 1484, 1485, 1486, 1487, 1488, 1489, 1490, 1491, 1492, 1493, 1494, 1495, 1496, 1497, 1498, 1499, 1500, 1501, 1502, 1503, 1504, 1505, 1506, 1507, 1508, 1509, 1510, 1511, 1512, 1513, 1514, 1515, 1516, 1517, 1518, 1519, 1520, 1521, 1522, 1523, 1524, 1525, 1526, 1527, 1528, 1529, 1530, 1531, 1532, 1533, 1534, 1535, 1536, 1537, 1538, 1539, 1540, 1541, 1542, 1543, 1544, 1545, 1546, 1547, 1548, 1549, 1550, 1551, 1552, 1553, 1554, 1555, 1556, 1557, 1558, 1559, 1560, 1561, 1562, 1563, 1564, 1565, 1566, 1567, 1568, 1569, 1570, 1571, 1572, 1573, 1574, 1575, 1576, 1577, 1578, 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1745, 1746, 1747, 1748, 1749, 1750, 1751, 1752, 1753, 1754, 1755, 1756, 1757, 1758, 1759, 1760, 1761, 1762, 1763, 1764, 1765, 1766, 1767, 1768, 1769, 1770, 1771, 1772, 1773, 1774, 1775, 1776, 1777, 1778, 1779, 1780, 1781, 1782, 1783, 1784, 1785, 1786, 1787, 1788, 1789, 1790, 1791, 1792, 1793, 1794, 1795, 1796, 1797, 1798, 1799, 1800, 1801, 1802, 1803, 1804, 1805, 1806, 1807, 1808, 1809, 1810, 1811, 1812, 1813, 1814, 1815, 1816, 1817, 1818, 1819, 1820, 1821, 1822, 1823, 1824, 1825, 1826, 1827, 1828, 1829, 1830, 1831, 1832, 1833, 1834, 1835, 1836, 1837, 1838, 1839, 1840, 1841, 1842, 1843, 1844, 1845, 1846, 1847, 1848, 1849, 1850, 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, 1862, 1863, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1884, 1885, 1886, 1887, 1888, 1889, 1890, 1891, 1892, 1893, 1894, 1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947, 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042,

EOL 1+2

REACTOR 3

SHEET 7C (m) P.T.

7

COOLING TOWER WATER PUMPS FAIL MECHANICALLY

$\Theta =$
 .7 IMPELLOR
 1.4 WEAROUT
 2.0 BLOCKAGES
 .7 COUPLING
4.8

$$\left(\frac{4.8}{40}\right)(1\%/y) = .12\%/y$$

OR GATE $.0055 + .0048 + .12 = .1303$

 Δ 7D
 U
STRIPPER FEED (REACTOR RECYCLE) PUMPS FAIL ELECTRICALLY

$\Theta =$
 8.4 MOTOR
 1.4 ELECTRICAL
9.8

$$.098 (3.3\%/y \text{ PUMPING SINGLE ORGANICS})$$

$$\Theta = .3234$$

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PUMP S/O ALARM FAILS

$$D = .3234$$

$$\Theta = .09 \text{ ALARM + CONTACTS}$$

$$H = .007$$

$$N = D + H = .3164$$

OPERATOR FAILS TO RESPOND

$$D = .3164 \quad \Theta = P_f = .02$$

$$H = .0063$$

STRIPPER FEED (REACTOR RECYCLE) PUMPS FAIL MECHANICALLY

$$\Theta = .048(3.3) = .1584$$

REACTOR LCV 1041 FAILS CLOSED

TRANSMITTER	$.63 \times \frac{1}{2} \times \frac{1}{3} =$	.105
CONTROLLER	$.29 \times \frac{1}{2} \times \frac{1}{3} =$	.0483
VALVE	$.24 \times \frac{1}{3} \times \frac{1}{3} =$	.053
POSITIONER	$.24 \times \frac{1}{2} \times \frac{1}{3} =$	.09
		<u>.2103</u> - Θ

SL 012447

OR GATE $.2103 + .1584 + .0063 + .007 = .382$

EDC 1+2

REACTOR 3

SHEET 7C

6m, P T

7D

REACTOR LOW LEVEL ALARM FAILS

$$D = .382 \quad \Theta = .04 \quad T = .5$$

$$H = .0036(2) \quad N_0 = D - H = .3784$$

OPERATOR FAILS TO RESPOND

$$D = .3784 \quad P_{F1} = .72 \quad D_1 =$$

$$P_{F2} = .02 \quad D_2 = (.0063 / .382) \cdot 3784 = .0062$$

$$H = D \cdot P_{F1} + D_2 P_{F2}$$

$$= .3722(.02) + .0062(.04)$$

$$= .0074 + .0002 = .0076$$

$$\text{OR GATE} \quad .0076 + .0036 = .0112$$

REACTOR LOW LEVEL S/D INPUT FAILS

$$D = .0112 \quad \Theta = \text{INPUT(PLC)} \cdot .0452$$

$$\begin{array}{r} LT \quad .105 \\ LS \quad .06 \\ \hline .2102 \end{array}$$

$$H = .0006(1)$$

$$N_0 = D - H = .0106$$

$$\text{OR GATE} \quad .0106 + .1303 + .4198 = .5607$$

REACTOR HIGH PRESSURE ALARM FAILS

$$D = .5607 \quad \Theta = .04 \quad T = .5$$

$$H = .0052(2)$$

$$N_0 = D - H = .5555$$

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7D

HICKS
P 52

EDC 1+2

REACTOR 3

SHEET 7D Gms P.T.

OPERATION FAILS TO RESPOND

$$D = .5555 \quad P_{L1} = .02 \quad D_1 = .5441$$

$$P_{L2} = .09 \quad D_2 = (.0114 / .5555) .5555 = .0115$$

$$H = D_1 P_{L1} + D_2 P_{L2}$$

$$.5441(.02) + .0115(.09)$$

$$.0109 + .0010 = .0119$$

$$\text{OR GATE} \quad .0114 + .0002 = .0116$$

REACTOR HIGH PRESSURE S/O INPUT FAILS

$$D = .0166 \quad \theta = .0452 \quad T = .5$$

$$H = .00019 \quad NO = D - H = .0164 \quad \Delta$$

$$\text{OR GATE} \quad .0106 + .0164 = .027$$

SHUT DOWN SYSTEM FAILS

$$D = .027 \quad FDT = .05 \quad \text{SOS BY PASSED} \quad 2-3 \text{ TIMES/WEEK}$$

$$H = .00135 \quad NO = D - H = .02565 \quad (2-3 \text{ HRS EACH TIME})$$

(TALKS W/ JUVES + CHDRY)

$$D = .02565 \quad \theta = .0452 \quad \text{S/O INPUT (ALC) FAILS}$$

$$H = .00029 \quad NO = D - H = .02536$$

$$D = .02536 \quad \text{C}_2\text{H}_4 + \text{C}_2\text{ VALVES FAIL TO CLOSE}$$

$$\theta = .073 \text{ C}_2\text{ VALVE}$$

$$H = .00046 \text{ C}_2$$

$$\theta = .073 \text{ C}_2\text{H}_4 \text{ FCV} + \text{PCV } 1/2$$

$$H = .00001$$

$$H_T = .00135 + .00029 + .00046 + .00001$$

$$= .00211$$

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EDC 142

REACTOR 3

SHEET 7D 6m2 P.T.

PT 3004 FAILS LOW

$$.3 \times \frac{1}{2} \times \frac{1}{2} = .05$$

OPERATOR FAILS TO NOTICE OR RESPOND CORRECTLY

$$D = .05 \quad \Theta = P_{\text{f}} = .5 \text{ TO NOTICE } .5 \text{ OF THAT TO RESPOND CORRECTLY}$$

$$H = .0375 \quad \text{O } P_{\text{f}}' = .75$$

CL₂ LOW FLOW ALARM FAILS

$$D = .0375 \quad \Theta = .04 \quad T = .5$$

$$H = .000375$$

OPERATOR FAILS TO RESPOND

$$D = .037125 \quad P_{\text{f}} = .9 \quad F_1 = .1 \quad F_2 = 1 \quad F_3 = 1 \quad F_4 = 3 \quad F_5 = 3$$

$$H = .0334125$$

$$\text{OR GATE } .0334125 + .000375 = .03379$$

$$\text{OR GATE } .00019 + .00211 + .03379 = .0361$$

RD/SRV RELIEVES EVERY

27.7 YRS

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EDC 1+2

React, R3

Sheet 7D Gm P.T.

PT 3004 FAILS CAUSING PCV 3004

RECOMMENDATION
REDAUNDANT PT

T, FAIL CLOSED

$$\theta = .3 \times \frac{1}{2} \times \frac{1}{3} = .05$$

REDAUNDANT PT FAILS

D: .05

$\theta = .05$

T: .5

H: .0000

$$H \cdot D \cdot T = .0494$$

OPERATOR FAILS TO RESPOND

D: .0494

P: .02

H: .001

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OR GATE

$$.001 + .0006 = .0016$$

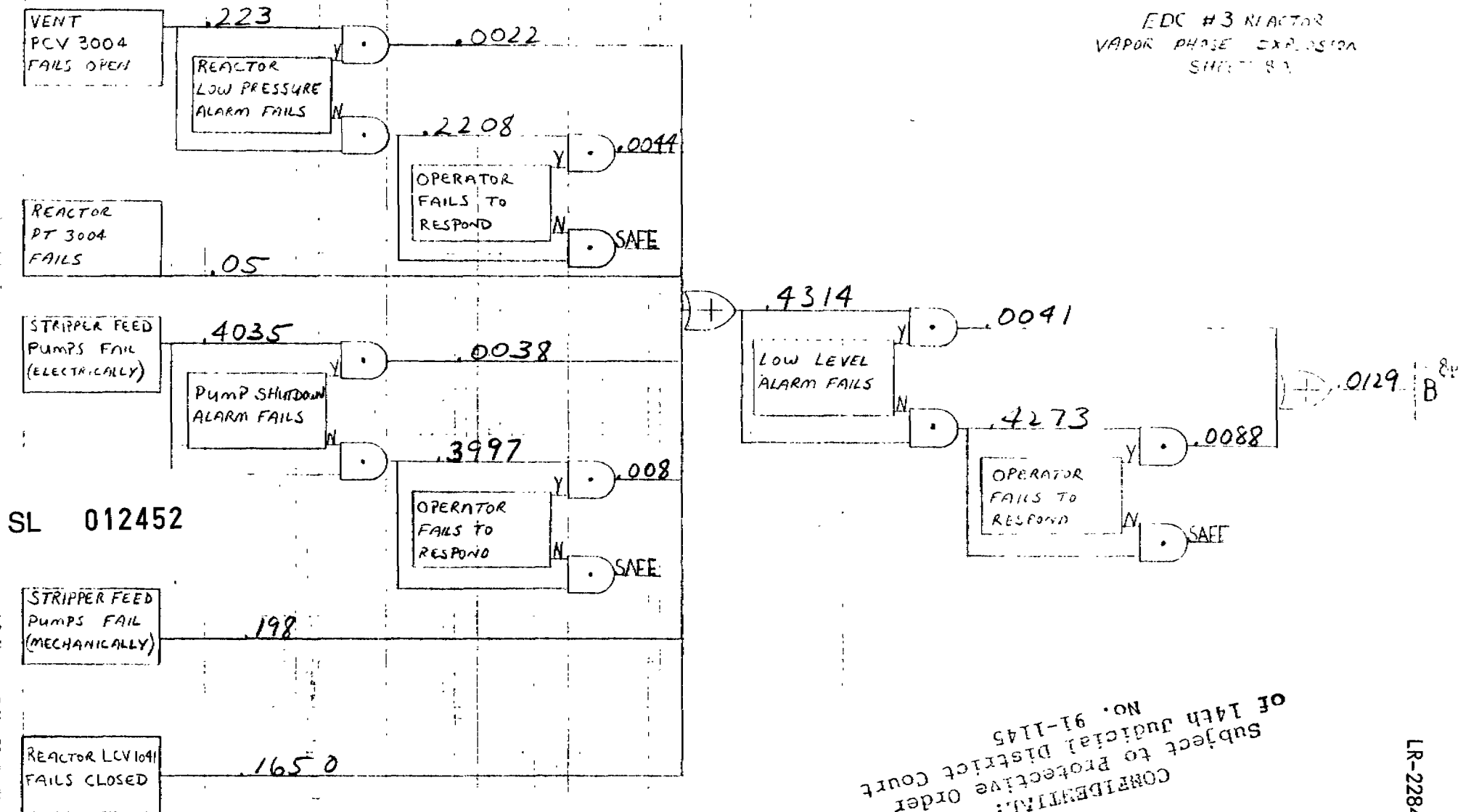
$$\text{OR GATE } .0016 + .00211 + .00019 = .0039$$

EXISTING SYSTEM
FAILURES

RO/REV
RELEASE

EVERY
257 YRS

EDC #3 REACTOR
VAPOR PHASE EXPLOSION
SHOOT 81



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EDC 1 + 2

#3 REACTOR

SILET 8A Gmo P.T

VAPOR PHASE EXPLOSION

VENT PCV 3004 FAILS OPEN

CONTROLLER PC $.29 \times \frac{1}{2} \times \frac{1}{3} = .0483$
 TRANSDUCER $.49 \times \frac{1}{2} \times \frac{1}{3} = .0817$

PV $.24 \times \frac{2}{3} \times \frac{1}{3} = .053$
 POSITIONER $.24 \times \frac{1}{2} \times \frac{1}{3} = .04$
 $.223 = \Theta$

REACTOR LOW PRESSURE ALARM FAILS

D = .223 $\Theta = .04$ T = .5

H = .0022 (1) $N_0 = D - H = .2208$

OPERATOR FAILS TO RESPOND

D = .2208 $P_f = .02$

H = .0044

PT 3004 FAILS

$.3 \times \frac{1}{2} \times \frac{1}{3} = .05$

STRIPPER FLOD PUMPS FAIL (ELECTRICALLY)

FRU - HECHLE 1.65 F/y FOR PUMPS HANDLING SINGLE ORGANICS
 (NON SEAL FAILURES)

MOTOR 8.4
 ELECT $\frac{1.4}{9.8}$ $1.65 (9.8/40) = .4035$

PUMP S/D ALARM FAILS

D = .4035 $\Theta = .04$ T = .5

H = .0038

OPERATOR FAILS TO RESPOND

D = .3997 $P_f = .02$

H = .008

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EDC 1 + 2

REACTOR 3

SHEET 8A (comp. T)

STRIPPER FEED PUMPS FAIL MECHANICALLY

H/C HLE 1.65 $\frac{5}{4}$ FOR PUMPS HANDLING SINGLE ORGANIC
 (NON SELF HEATING)
 IMPELLOR .7
 WINDOUT 1.4
 COUPLING .7
 BLOCKAGE $\frac{2.2}{4.8}$
 $1.65 (4.8/40) = .198$

REACTOR LCV 1041 FAILS CLOSED

CONTROLLER .29 $\times \frac{1}{2} \times \frac{1}{3} = .0483$
 TRANSMITTER LT1037 .3 $\times \frac{1}{2} \times \frac{1}{3} = .05$
 POSITIONER .24 $\times \frac{1}{2} \times \frac{1}{3} = .04$
 LCV 1041 .24 $\times \frac{1}{3} \times \frac{1}{3} = .0267$
 $\underline{.1650}$

OR GATE

$$.1650 + .198 + .008 + .0038 + .05 + .0044 + .0022 = .4314$$

LOW LEVEL ALARM FAILS

$$D = .4314 \quad \theta = .04 \quad T = .5$$

$$H = .0041$$

OPERATOR FAILS TO RESPOND

$$D = .4273 \quad P_{f1} = .02 \quad D_1 = .415$$

$$P_{f2} = .04 \quad D_2 = (.0124 / .4314) \cdot .4273 = .0123$$

$$H = D_1 P_{f1} + D_2 P_{f2}$$

$$= .415(.02) + .0123(.04)$$

$$= .0083 + .0005$$

$$= .0088$$

$$\underline{\text{OR GATE}} \quad .0041 + .0088 = .0129$$

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42 SHEETS 3 QUARTS
 42 SHEETS 3 QUARTS
 42 SHEETS 3 QUARTS



LOW LEVEL S/D INPUT FAILS

D = .0129 Θ .0952 T = .5

H = .000145 NO D-H = .0127

C₁ ANALYZER INVERT FAILS $\frac{1}{2}$

D = .000145 Θ .6 SLIGHTLY HIGHER THAN C₂ ANALYZER (5.6) at 2-11-77
PER CHARLES LONG

H = .000163 T = .019 1/WT

ANALYZER ALARM FAILS

D = .000144 Θ .04 T = .5

H = .00000144 NO = D-H = .000143

OPERATOR FAILS TO RESPOND

D = .000143 PF = .5 DUE TO TIME

H = .000071

OR GATE .0000014 + .000071 = .000073

ANALYZER S/D INPUT FAILS

D = .000073 Θ = .0452 T = .5

H = .00000082 NO = D-H = .000072

OR GATE .000072 + .0127 = .012772

S/D SYSTEM FAILS

D = .012772 EDT = .05 S/D SYSTEM BY PASSED 2-3 TIMES/WT
H = .0006386 2-3 HRS/TIME
NO = D-H = .012133 PER MARIO JUNE

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EDC 1+2 REACTOR 3 SHEET 8B 6mo P.T.

SOS FAILS CONT

S/D INPUT (PLC) SIGNAL FAILS

$$D = .012133 \quad \Theta = .0452 \quad T = .5$$

$$H = .00013711$$

$$Y_0 = D - H = .0119963$$

CL VALVE FAILS TO CLOSE

$$D = .0119963$$

$$\Theta = .073$$

$$T = .5$$

FROM R.E. HANDBOOK
TABLE 4 FAILURE RATES
DID NOT ELIMINATE
SLOW FAILURES SINCE S/D
FEATURE COULD FAIL SLOWLY.

$$H = .00021893$$

$$H_T = .00021893$$

$$.00013711$$

$$.0006386$$

$$.00099464$$

$$\text{ORGATE} \quad .00099464$$

$$.00000082$$

$$.00000063$$

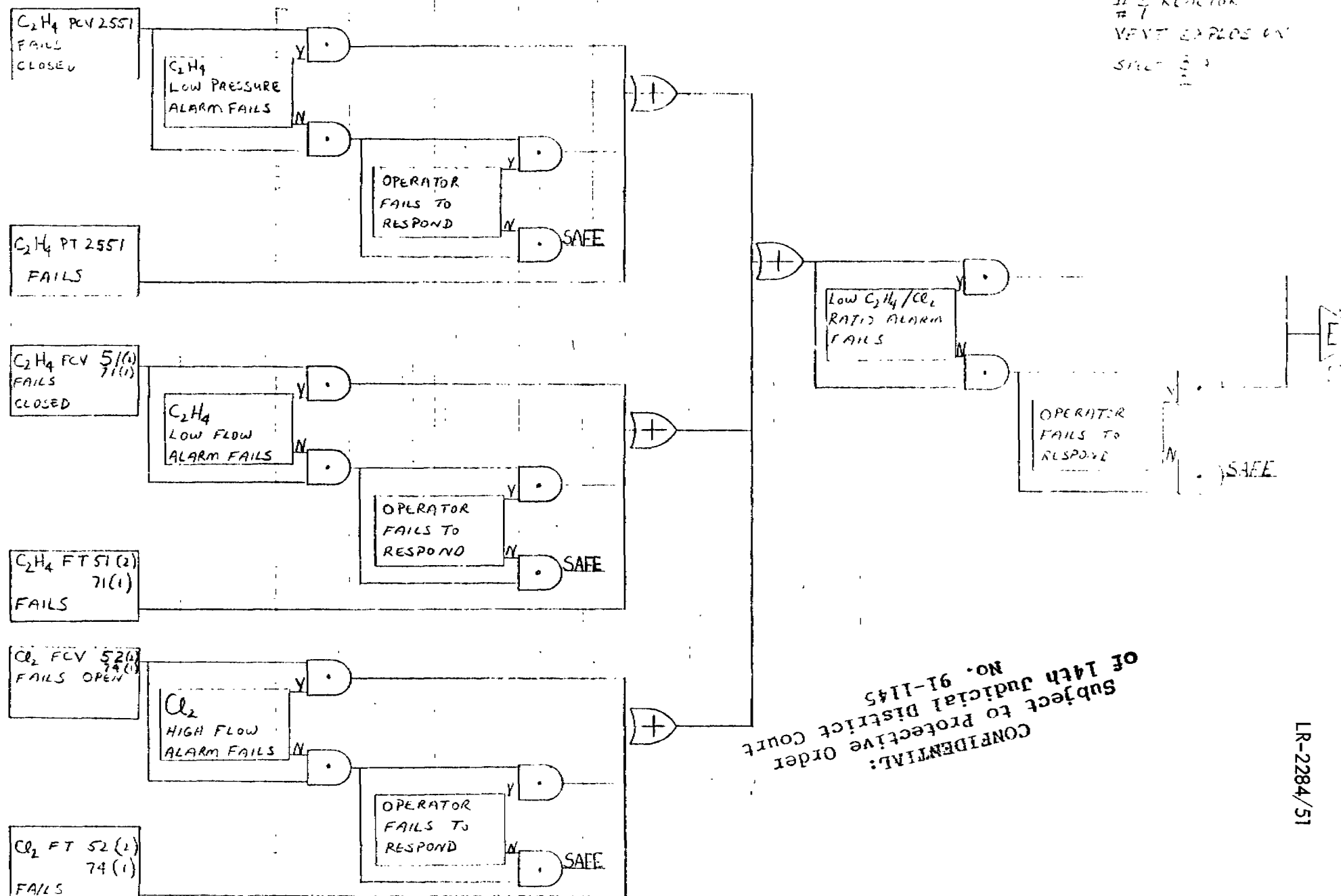
$$.00099609$$

POSSIBLE VAPOR PHASE
REACTION/EXPLOSION

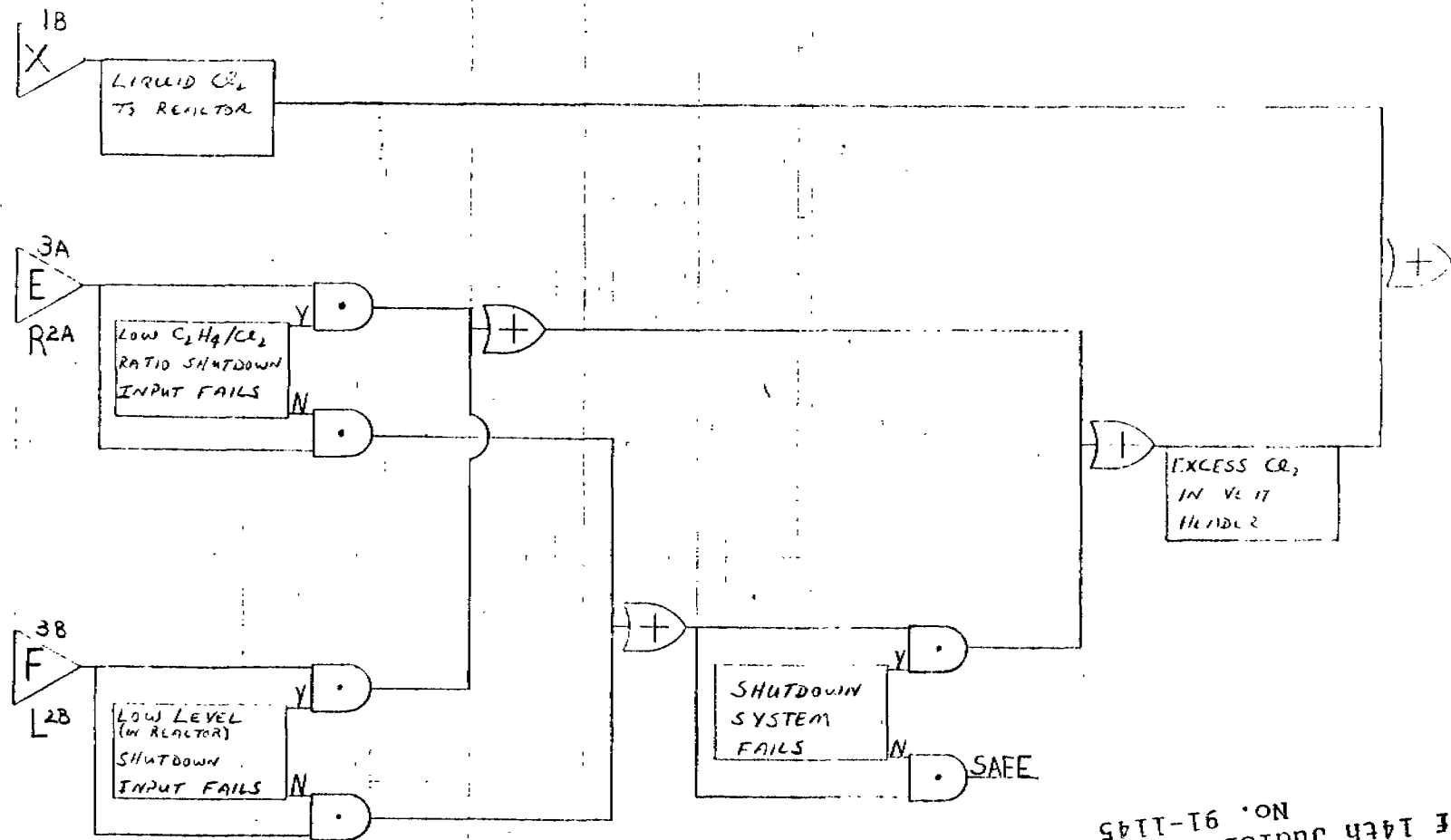
EVERY 1004 YRS

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#2 P. 100
#7
V. 100.05 10
S. 100.05 10

P. 100.05 10
S. 100.05 10

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SL 012460

LR-2284/53

SL 012461

C₂H₄ FCV 51(6)
71(6)
FAILS
OPEN

C₂H₄ FT 51(1)
71(1)
FAILS

Cl₂ FCV 52(2)
FAILS 74(1)
CLOSED

LOSS OF Cl₂
FLOW FROM
LIQUEFACTION

Cl₂ PCV 56
FAILS
CLOSED

C₂H₄ PCV 2551
FAILS
OPEN

C₂H₄ PT 2551
FAILS

HIGH C₂H₄
FLOW ALARM
FAILS

Cl₂ HEADER
PRESSURE
ALARM FAILS

C₂H₄ HIGH
PRESSURE
ALARM FAILS

OPERATOR
FAILS TO
RESPOND

OPERATOR
FAILS TO
RESPOND

OPERATOR
FAILS TO
RESPOND

SAFE

SAFE

SAFE

Cl₂ FT 52(1)
FAILS 74(1)

LOW Cl₂ FLOW
ALARM FAILS

OPERATOR
FAILS TO
RESPOND

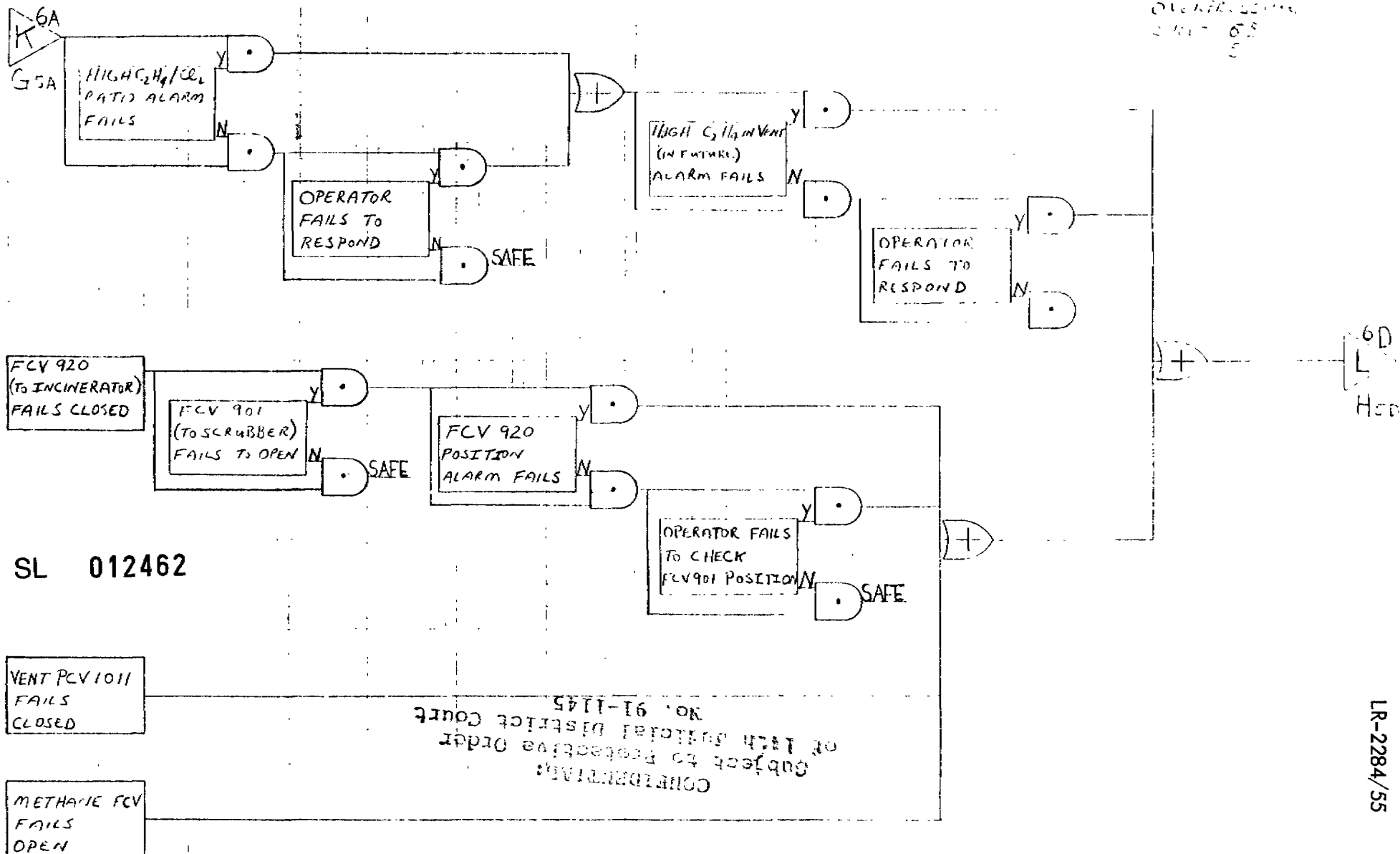
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2 REASON
OVERSPEECH
SHEET 6th
5

LR-2284/54

K⁶
Go.

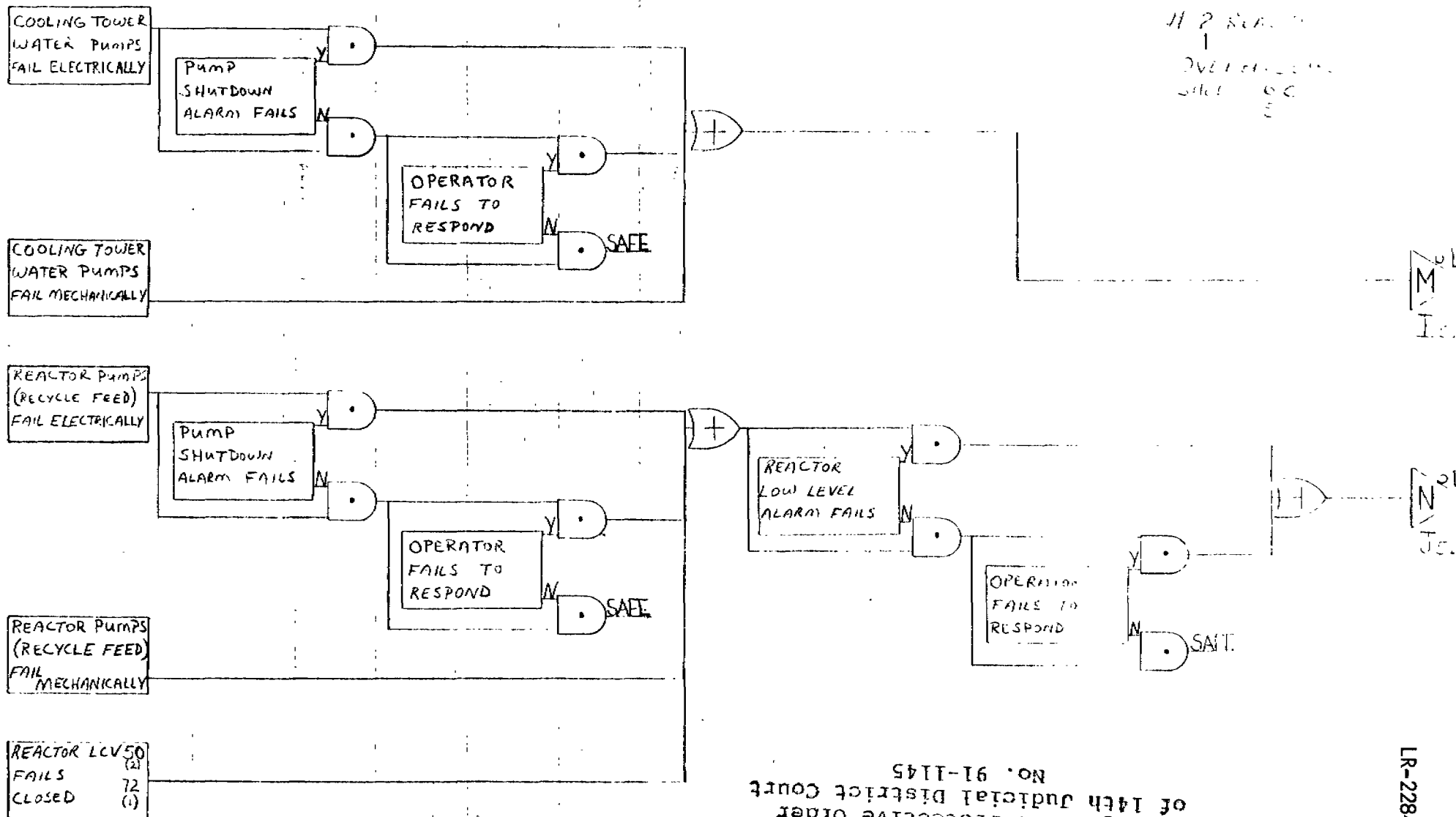
APPROX
 OVER 2000
 2007-08



SL 012462

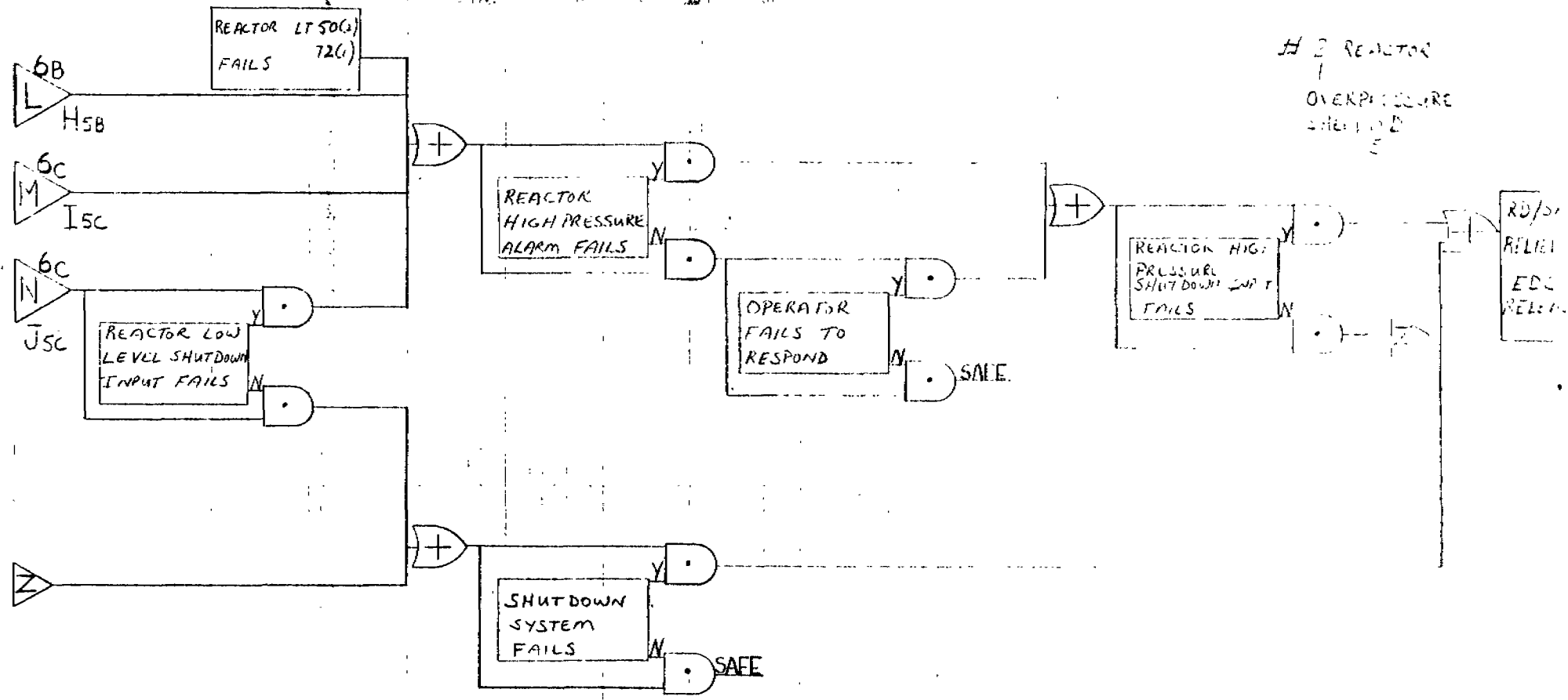
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LR-2284/56



H2 REACTOR
OVERPRESSURE
SHUT DOWN

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LR-2284/57

SL 012464

EDC RELEASE FROM #3 REACTOR

PRODUCTION RATE 620 TPD

EDC BOILUP RATE 620 (6) = 3720 TPD

$$\frac{3720 \text{ TONS DAY}}{\text{DAY} \mid 24 \text{ HR}} \mid \frac{\text{HR}}{60 \text{ MIN}} = 2.58 \text{ TONS/MINUTE}$$

$$Q = \frac{A C K P \sqrt{m}}{\sqrt{T} \sqrt{2}} =$$

$$= \frac{50.27 (315) (6) (64.7) (9.9484)}{25.5}$$

$$= 239867.6 \text{ \# HR}$$

$$= 1.9989 \text{ TON/MIN}$$

$$A = \frac{\pi (8)^2}{4} = 50.27$$

$$C = 315$$

$$K = .6$$

$$P = 50 + 14.7 \cdot 64.7$$

$$\sqrt{m} = \sqrt{98.97} = 9.9484$$

$$2 = 1$$

$$T = 190 + 460 = 650^\circ \text{R}$$

$$\sqrt{T} = 25.5$$

RELEASE FROM RUPTURE DISC + BOILUP RATE BOTH
EXCEEDED 1 TON/MIN SO TOXIDISP WAS RUN
TO DETERMINE POSSIBILITY OF VAPOR CLOUD FORMATION
REACHING AN IGNITION SOURCE. THE COMPUTER
RUN SHOWED THIS RELEASE TO BE A MINIMAL
HAZARD.

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WHAT NEXT? PCD

19.TITLE: EDC 2

20.TOXIC: CL2

21.LOCATION: METCHARL

BOUNDARY DISTANCES, BLDG HTS, BLDG DISTANCES (M):

1	335	1	125
2	318		
3	353		
4	564		
5	708	1	35
6	819		
7	826		
8	964		
9	1514	3	85
10	1246		
11	1092		
12	865		
13	786		
14	783	3	190
15	718		
16	639		
17	625		
18	350		

22 STACK DIAM (M) 0.1016

23 STACK HT (M) 30

24 BUILDING HT (M) 0

25 GAS RATE (RM3/HR) 5577.24

COMPONENT

LB /HR

TEMP

CL2 *36240.00 25.0

26 GAS MOL. WT. 70.914

27 GAS TEMP (C) 25

28 GAS SP HT (J/KG.C) 484.8

29 TOXIC CONC (ZU/V) 100

30 DURATION (MIN) 0.5

31 SMALL TABLE WIND 0

32 SMALL TABLE WTHR. 0

33 SURFACE R'NESS(M) 0.1

34 ISOPLETH CONC(PFM) 0

94 EFFLUX ANGLE (DEG) 90.

95 AMBIENT TEMP (*C) 21

96 AMBIENT PRESS(BAR) 1.013

WHAT NEXT? NEW20

OLD TOXIC WAS CL2

20.TOXIC? EDC

ALL EXISTING STACK GAS DATA ZEROED.

GAS NAME NOT FOUND - HAVE YOU MIS-SPELT IT? N

CONCS FOR 1 AND 10 MINS.

HELP? 4000,2000

TOO MUCH INPUT--EXCESS IGNORED

HELP? N

CATEGORY 1 ? 4000,2000

CATEGORY 2 ? 6000,5000

CATEGORY 3 ? 9000,8000

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LR-2284/59

WHAT NEXT? NEW22/23/25
OLD VALUE FOR 22 STACK DIAM (M) WAS 0.1016
NEW VALUE? .2032

NEW23/25
OLD VALUE FOR 23 STACK HT (M) WAS 30
NEW VALUE? 17

NEW25
OLD VALUE FOR 25 GAS RATE (RM3/HR) WAS 0
NEW VALUE? 122.6

WHAT NEXT? NEW26/27/28
OLD VALUE FOR 26 GAS MOL. WT. WAS 0
NEW VALUE? 98.97

NEW27/28
OLD VALUE FOR 27 GAS TEMP (C) WAS 0
NEW VALUE? 88

NEW28
OLD VALUE FOR 28 GAS SP HT (J/KG.C) WAS 0
NEW VALUE? 951.5

WHAT NEXT? PCD

19.TITLE: EDC 2
20.TOXIC: EDC
1 MIN 10 MINS
CAT 3 9000.00 8000.00
CAT 2 6000.00 5000.00
CAT 1 4000.00 2000.00

21.LOCATION: METCHARL

BOUNDARY DISTANCES, BLDG HTS, BLDG DISTANCES (M):

1	335	1	125
2	318		
3	353		
4	564		
5	708	1	35
6	819		
7	826		
8	964		
9	1514	3	85
10	1246		
11	1092		
12	865		
13	786		
14	783	3	190
15	718		
16	639		
17	625		
18	350		

22 STACK DIAM (M) 0.2032
23 STACK HT (M) 17
24 BUILDING HT (M) 0
25 GAS RATE (RM3/HR) 122.6

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LR-2284/60

28 HT (J/KG.C) 951.5
 29 TALL CONC (XV/V) 0
 30 DURATION (MIN) 0.5
 31 SMALL TABLE WIND 0
 32 SMALL TABLE WTHR. 0
 33 SURFACE R'NESS(M) 0.1
 34 ISOPLETH CONC(PPM) 0
 94 EFFLUX ANGLE (DEG) 90.
 95 AMBIENT TEMP (*C) 21
 96 AMBIENT PRESS(BAR) 1.013

SL 012468

WHAT NEXT? WRI

FILE NAME? EDC12

WHAT NEXT? COM02

EXIT VELOCITY (M/S) = 1.2937
 APPROX. .7 % SONIC VELOCITY.

1.1	1.2	1.3
2.1	2.2	2.3
3.1	3.2	3.3
4.1	4.2	4.3
5.3	5.4	
6.1	6.2	6.3

CAT.	PROB(%)	CUM.PROB(%)	LIMITING CONC(PPM)
3	.000	.000	9324.83
2	.000	.000	6338.51
1	.000	.000	4928.09
0	100.000	100.000	.00

FLOW 122.6
 BURN 0.5
 EDC 2

WHAT NEXT? COM03

ENTER TERMINAL WIDTH, 72 OR 132? 132

1.1	1.2	1.3
2.1	2.2	2.3
3.1	3.2	3.3
4.1	4.2	4.3
5.3	5.4	
6.1	6.2	6.3

DIRECTION	2	1	18	3	4	17	16	5	15	14	13	6	7	12	8	11	10	9	MAXIMUM	ESH
DISTANCE	318	335	350	353	564	625	639	708	718	783	786	819	826	865	964	1092	1246	1514	CONC	DIST
BLDG. HT.	0	1	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	3		
BLDG. DIST.	0	125	0	0	0	0	0	35	0	190	0	0	0	0	0	0	0	85		
XPROB CAT. 3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0		
XPROB CAT. 2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0		
XPROB CAT. 1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0		
XPROB CAT. 0	4.3	7.0	10.7	3.3	2.4	5.9	6.9	2.3	5.8	7.3	8.5	2.1	2.8	7.6	3.3	6.1	6.3	7.3		

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LR-2284/61

CAT.	PROB(%)	CUM.PROB(%)	LIMITING CONC(PPM)
3	.000	.000	9324.83
2	.000	.000	6338.51
1	.000	.000	4928.09
0	100.000	100.000	.00

FLOW 122.6
BURN 0.5
EDC 2

WHAT NEXT? NEW34
OLD VALUE FOR 34 ISOPLETH CONC(PPM) WAS 0
NEW VALUE? 28000

WHAT NEXT? COM02
BUILDING TOP (T), BUILDING WHOLE (W), OR HELP (-999)? W

1.1	1.2	1.3				
2.1	2.2	2.3	2.4			
3.1	3.2	3.3	3.4	3.5	3.6	
4.1	4.2	4.3	4.4	4.5	4.6	
5.3	5.4					
6.1	6.2	6.3				

CAT.	PROB(%)	CUM.PROB(%)	LIMITING CONC(PPM)
3	.000	.000	9324.83
2	.000	.000	6338.51
1	.000	.000	4928.09
0	100.000	100.000	.00

AREA OF 28000 PPM ISOPLETH BEYOND BOUNDARY (M2) * ACTUAL PROB= 0

PROB(%) OF 28000 PPM ISOPLETH STRIKING ANYWHERE ON BUILDING.

SECTOR	BLDG.HT.	BLDG.DIST.	PROB.(%)
1	1	125	.000
5	1	35	.000
9	3	85	.000
14	3	190	.000

FLOW 122.6
BURN 0.5
EDC 2

WHAT NEXT? NEW34
OLD VALUE FOR 34 ISOPLETH CONC(PPM) WAS 28000
NEW VALUE? 2000

WHAT NEXT? COM02
BUILDING TOP (T), BUILDING WHOLE (W), OR HELP (-999)? W

1.1	1.2	1.3				
2.1	2.2	2.3	2.4			
3.1	3.2	3.3	3.4	3.5	3.6	
4.1	4.2	4.3	4.4	4.5	4.6	

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LR-2284/62

6

CAT.	PROB(%)	CUM.PROB(%)	LIMITING CONC(PPM)
3	.000	.000	9324.83
2	.000	.000	6338.51
1	.000	.000	4928.09
0	100.000	100.000	.00

AREA OF 2000 PPM ISOPLETH BEYOND BOUNDARY (M2) * ACTUAL PROB= 0

PROB(%) OF 2000 PPM ISOPLETH STRIKING ANYWHERE ON BUILDING.

SECTOR	BLDG.HT.	BLDG.DIST.	PROB.(%)
1	1	125	.000
5	1	35	.000
9	3	85	.000
14	3	190	.000

FLOW 122.6
BURN 0.5
EDC 2

WHAT NEXT? NEW34
OLD VALUE FOR 34 ISOPLETH CONC(PPM) WAS 2000
NEW VALUE? 100

WHAT NEXT? COM02
BUILDING TOP (T), BUILDING WHOLE (W), OR HELP (-999)? W

1.1	1.2	1.3			
2.1	2.2	2.3	2.4		
3.1	3.2	3.3	3.4	3.5	3.6
4.1	4.2	4.3	4.4	4.5	4.6
5.3	5.4				
6.1	6.2	6.3			

CAT.	PROB(%)	CUM.PROB(%)	LIMITING CONC(PPM)
3	.000	.000	9324.83
2	.000	.000	6338.51
1	.000	.000	4928.09
0	100.000	100.000	.00

AREA OF 100 PPM ISOPLETH BEYOND BOUNDARY (M2) * ACTUAL PROB= 0

PROB(%) OF 100 PPM ISOPLETH STRIKING ANYWHERE ON BUILDING.

SECTOR	BLDG.HT.	BLDG.DIST.	PROB.(%)
1	1	125	.000
5	1	35	.000
9	3	85	.000
14	3	190	.000

FLOW 122.6
BURN 0.5
EDC 2

WHAT NEXT? END

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LR-2284/63

$$A = \frac{\pi b^2}{4} = 28.27$$

$C = 315$

$$p = 50 + 14.7 = 64.7$$
$$\sqrt{m} = \sqrt{98.97} = 9.9484$$

211

$$T = 190 + 460 = 650^{\circ}\text{R}$$
$$\sqrt{T} = 25.495$$

$$Q = \frac{A C K P \sqrt{m}}{\sqrt{T} \sqrt{Z}}$$

$$= \frac{28.27 (315) (.6) (64.7) (9.9489)}{25.495}$$

$$= 134,913.9 \text{ \# / HR}$$

$$= 1.1243 \text{ TONS / MINUTE}$$

$$(88' - 54(1.5') = 7')$$

$(88' - 54(1.5') = 7')$
 Plus 1" EDC ON EACH TRAY $(54(1")/12" = 4.5')$
 $7' + 4.5' = 11.5'$

$$\text{Volume of } C = \frac{\pi (5.7)^2}{4} (11.5') = 292$$

DENSITY OF EDC @ 190°F = 71.14 #/FT³

$$\# \text{ EDC IN STILL} = 292 (71.14) = 20,784.7 \#$$

$$\text{MINUTES OF RELEASE (MAXIMUM)} = 20,784.7 \pm \left(\frac{\text{HR}}{134913.9 \pm} \right) \frac{60 \text{ min}}{\text{HR}} = 9.24 \text{ min}$$

Thus release similar to OHC II Light Still which proved to present minimal vapor cloud hazard as there was ~~no~~ duplicate run on TSX1DISP.

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EDC #2 STILL

$$A = \frac{\pi (8)^2}{4} = 50.265$$

K = .6 FOR RD.

C = 315

P = 50 + 14.7 = 64.7 psia

 $\bar{M} = \frac{98.97}{1} = 9.9484$

T = 190 + 460 = 650°R

 $\bar{T} = 25.495$

$$Q = \frac{ACK\sqrt{P}\bar{M}}{\sqrt{T} \cdot \bar{T}}$$

$$= \frac{50.265(315)(.6)(64.7)(9.9484)}{25.495}$$

$$= 239,843.7 \text{ #/HR}$$

$$= 1.9986 \text{ Ton/min}$$

ASSUME SPACE NOT CONTAINING TRAYS CONTAINS
EDC. (95' - 54(1.5') = 14') PLUS 1" EDC
ON EACH TRAY (54(1")/12" = 4.5'). 18.5' EDC

$$\text{VOLUME EDC} = \frac{\pi (7')^2 (18.5')}{4} = 711.96 \text{ ft}^3$$

$$\text{DENSITY OF EDC @ } 190^\circ\text{F} = 71.14 \text{ #/ft}^3$$

$$\text{# EDC IN STILL} = 711.96 (71.14) = 50,649.6 \text{ #}$$

$$\text{MINUTES TO RELEASE (MAXIMUM)} = 50,649.6 \text{ #} \left(\frac{\text{HR}}{239,843.7} \right) \frac{60 \text{ MIN}}{\text{HR}} = 12.67 \text{ min}$$

This release is similar to OHC II Lights Still which
proved to present minimal vapor cloud hazard
so there was no duplicate run on TOXIDISP.

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EDC #1 STRIPPER

$$A = \frac{\pi 4^2}{4} = 12.566$$

 $\pi = .6$ FOR R.D.

 $C = 315$
 $P = 50 + 14.7 = 64.7$

$$\sqrt{m} = \sqrt{98.97} = 9.9484$$

 $Z = 1$
 $T = 190 + 460 = 650^\circ R$
 $= 25.495$

$$Q = \frac{ACITP\sqrt{m}}{\sqrt{Z}\sqrt{T}}$$

$$= \frac{(12.566)(315) \cdot 6 (64.7)(9.9484)}{25.495}$$

$$= 59,961.7 \text{ #/HR}$$

$$= .4997 \text{ TONS/MINUTE}$$

ASSUME SPACE NOT CONTAINING PACKING CONTAINS EDC
(28' - 18' = 10')

VOID FACTOR = .63 FOR BERL SADDLES

$$18' \times \frac{(4.75)^2 \pi}{4} = 318.96$$

$$318.96 \times .63 = 200.95 \text{ FT}^3 \text{ OF EDC}$$

$$10' \times \frac{(4.75)^2 \pi}{4} = 177.2 \text{ FT}^3 \text{ OF EDC}$$

$$\text{TOTAL} = 200.95 + 177.2 = 378 \text{ FT}^3 \text{ OF EDC}$$

$$\text{DENSITY OF EDC @ } 190^\circ F = 71.19 \text{ #/FT}^3$$

$$\# \text{ EDC IN STILL} = 378 (71.19) = 26,901.7 \text{ #}$$

$$\text{MINUTES OF RELEASE (MAXIMUM)} = 26,901.7 \left(\frac{\text{HR}}{59,961.7 \text{ #}} \right) \frac{60 \text{ MIN}}{\text{HR}} = 26.9 \text{ MIN}$$

This release did not meet the minimum criteria of 1 TON/minute to constitute a vapor cloud hazard $\therefore$ NO TOXIO.SP Rvw.

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EDC #2 STRIPPER

$$A = \frac{\pi(2)^2}{4} = 3.1416$$

$$C = 315$$

K = .6 FOR R.D

$$P = 50 + 14.7 = 64.7$$

$$\sqrt{m} = \sqrt{98.97} = 9.9484$$

$$Z = 1$$

$$T = 190 + 460 = 650^\circ R$$

$$= 25.495$$

$$Q = \frac{ACKP\sqrt{m}}{\sqrt{Z} \sqrt{T}}$$

$$= \frac{3.1416(315)(.6)(64.7)(9.9484)}{25.495}$$

$$= 14990.4 \#/HR$$

$$= .1249 \text{ TONS/MINUTE}$$

ASSUME SPACE NOT CONTAINING PACKING CONTAINS EDC
(29.25' - 20' = 9.25')

VOID FACTOR = .63 FOR BERL SADDLES

$$20' \times \frac{(5.5')^2 \pi}{4} = 475.2 \text{ ft}^3$$

$$475.2 \text{ ft}^3 \times .63 = 299.4 \text{ ft}^3 \text{ of EDC}$$

$$9.25 \times \frac{(5.5')^2 \pi}{4} = 219.8 \text{ ft}^3 \text{ of EDC}$$

$$\text{TOTAL } 299.4 + 219.8 = 519 \text{ ft}^3 \text{ of EDC}$$

$$\text{DENSITY OF EDC @ } 190^\circ F = 71.14 \#/\text{ft}^3$$

$$\# \text{ EDC IN STILL} = 519 (71.14) = 36,930 \#$$

$$\text{MINUTES OF RELEASE (MAXIMUM)} = \frac{36,930 \# \left(\frac{HR}{14,990} \right) \frac{60 \text{ MIN}}{HR}}{1} = 147.8$$

This release did not meet the minimum criteria of .1 TON/minute to constitute a vapor cloud hazard $\therefore$ NO TOXIDISP RUN.

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