

CENTRAL ENGINEERING - RES 608.1 02

CONFIDENTIAL
RELIABILITY STUDY
VINYL CHLORIDE MONOMER
EXPANSION

EDC CRACKING FURNACES,
DOWTHERM HEATER, AND
VCM II SUMMARY

by

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REVIEWED BY:

B. A. VIRNIG, PETROCON, INC.

NOVEMBER, 1980

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KEY WORD

RELIABILITY
VCM II

SL 012025

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INTRODUCTION

Upon completion of the OHC Reactor Study on August 5, 1980, work began on the EDC cracking furnaces, Dowtherm heater, light and heavy stills, and the VCM shift storage tanks. Another area that was considered was the combined OHC reactor and the liquid phase reactor vent system.

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ABSTRACT

This report covers the EDC cracking furnaces, Dowtherm heater, light and heavy stills, and the VCM shift storage tanks. The combined vent system including OHC reactor and liquid phase EDC reactor was studied also.

Years between explosions were determined using standard ICI fault tree analysis. Explosions were broken down between minor and major explosions. Minor explosions are those that cause little or no equipment damage but cause one or two days of equipment outage. Major explosions are those that cause up to one week or more equipment outage and danger to life of operating personnel.

Examples of minor explosions in the Dowtherm heater or EDC cracking furnace include small gas leaks that upon ignition cause minor damage such as dislodging explosion doors, breakage of burner and/or pilot tips, and minor damage to refractory. Explosion pressures generated by these types of explosions or fires would be contained by the vessel walls and would not cause any significant hazard to operating personnel.

Table I summarizes top events for the "Present" and "Proposed" cracking furnaces and the Dowtherm heater. Criteria for toxic gas releases and explosions are also listed. The present furnaces and heaters exceed the major explosion criteria for the entire VCM II expansion. The number of minor and major explosions can be reduced significantly with minimal capital investments such as valve position switches, input modules to the programmable logic computer (PLC) and use of on-line gas chromatography to provide a back-up system for explosive mixtures of chlorine ethylene and other inerts in the combined vent of OHC reactor and liquid phase EDC reactor.

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TABLE I

CRACKING FURNACE & DOWTHERM HEATER
YEARS BETWEEN OCCURRENCES

	<u>Events</u>	<u>Present</u>	<u>Proposed</u>	<u>Criteria</u>
I.	Toxic Releases			
	Category III	-	-	15-30
	Category II	-	-	2-5
	Category I	-	-	0.5
	Category 0	-	-	0.0192
II.	Minor Explosion	1.01	101	5-10
III.	Major Explosion	6.9	165	50-100

DISCUSSION AND RESULTS

This level III study of the Vinyl Chloride Monomer Phase II Plant Expansion details frequency and severity of both toxic gas omissions and hydrocarbon releases that could lead to minor or major explosions. Table II summarizes Hazard Rates for the "As Built" and "Revised" furnaces and Dowtherm Heater.

Cracking Furnaces, Fault Tree No. 1

Fault Tree No. 1 deals with shutdown and subsequent start up of the EDC Cracking Furnaces. The Furnace Shutdown System is detailed in the Appendix. As shown in the fault tree, all Factory Mutual cock valves, one tight shut off valve, and natural gas flow control valve are proved closed. Also pilot gas valve KV-3832 is proved closed. The status of 28 XV-A151-178 valves in the pilot gas line is unknown because the valves do not have position indicators. Upon subsequent start-up when one igniter is pushed and a flame is perceived by the Fire Eye, the natural gas is held open by the Flame Management System. If one or more of the 28 "XV" valves have "hung" in the open position, a pocket of flammable gas builds in the furnace until it reaches an ignition source. As seen from the fault tree, this small explosion, as defined in the fault tree support information, happens in both furnaces every 1.1 years. Installation of position switches on the 28 "XV" pilot gas valves reduces the number of small explosions to once every 257 years for both furnaces. Explosion pressures of 1.1 PSIG (see support information with fault tree) should cause only minor damage at most to the furnace such as dislodging the explosion door, burner and/or pilot tips, dampers, and small parts of the

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TABLE II
VCM II EXPANSION
CRACKING FURNACE & DOWTHERM HEATER
HAZARDS SUMMARY

FAULT TREE ID.		HAZARD RATE, TIME/YEAR		TOP EVENT
		AS BUILT	REVISED	
1*	EXCESS GAS UPON STARTUP	0.909	0.00389	MINOR EXPLOSION
2	FIRE IN FURNACE AFTER VAPOR DETECTOR S.D.	0.139	0.000725	MAJOR EXPLOSION
3	LOSS OF FLOW	0.0034	0.0034	FIRE IN FURNACE
4	FAILURE OF SNUFFING STEMS	0.0052	0.0052	MAJOR EXPLOSION
5	EXCESS GAS IN FURNACE	0.0034	—	—
6	TUBE FAILURE ON STARTUP	0.072	0.00050	FIRE IN FURNACE
1**	TUBE FAILURE, FLANGE LEAK	0.000004 0.00133	0.001034	FIRE IN HEATER
2	LOSS OF FLOW	0.00099	—	DOWTHERM CARBURIZATION
3	VOID	—	—	—
4	FIRE IN FURNACE AFTER VAPOR DETECTOR S.D.	0.00015	0.00015	MAJOR EXPLOSION
5	TEMP. LOOP FAILS OPEN	0.00007	—	DOWTHERM CARBURIZATION

* EDC CRACKING FURNACES - FAULT TREES #1 THRU #6

** DOWTHERM HEATER - FAULT TREES #1 THRU #5

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refractory. No structural damage is anticipated to the fire box or furnace tubes. Expected duration of furnace outage is two days or less.

Cracking Furnaces, Fault Tree No. 2

Fault Tree No. 2 deals with vapor detector initiated shut downs and the probability of a main gas valve failing open. Since the fuel gas vent valve is operator initiated, it is assumed that the majority of gas venting would be into the furnace prior to the operator's opening this valve. It would take an operator 10 to 15 seconds to analyze the cause of furnace shut down and the opening of the vent valve after this short duration means that a flame continued in the furnace after a vapor detector initiated shut down has occurred as seen from the fault tree. This situation can occur once every 7.2 years for both furnaces. Installation of a solenoid dump valve on HV-3834 to make operation of this valve automatic, instead of operator initiated, would reduce major explosions as a result of fires continuing in the furnace after vapor detector initiated shut downs from once every 7.2 years to once every 1380 years.

Cracking Furnaces, Fault Tree No. 3

Fault Tree No. 3 examines loss of crude EDC flow to the furnace and the back up systems to prevent tube rupture from over firing. (Refer to fault tree support information for overall FDT of the loss of flow shut down system.) The system as designed with a crude EDC flow loss of 0 to 75 percent (which will result in tube failure if the gas firing rate is not cut accordingly) will not alarm or cast a vote for shut down. The low flow shut down as designed is only 15 GPM and the alarm condition is 25 GPM. It is recommended to alarm and cast a vote for furnace shut down at design minus 20 and 33 percent respectively. These

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values are based on a constant firing rate with the additional fuel gas used to increase product outlet temperatures. (See page 7 of 7 of Fault Tree Support Information for more details.)

It is also recommended to cast a vote for shut down when Tube Metal Temperature exceeds 1500°F; alarm TMT when temperature exceeds 1400°F. (See page 6 of 7 for maximum allowable working pressure versus operating temperature).

The temperature and pressure relationship on the furnace tubes is based on the American National Standard Code for Pressure Piping. This analysis is more conservative than the power piping or boiler code. There is an 80% safety factor in the pressure piping analysis; however, the dotted curve on page 6 of 7 of the Fault Tree Support Data removes this safety factor. This new operative line should represent an approximate relationship between maximum allowable working pressure and operating temperature of the furnace tubes.

Cracking Furnaces, Fault Tree No. 4

Fault Tree No. 4 analyzes the failure of the snuffing steam when activated by a vapor detector shut down. Based on the fault tree analysis, it is recommended that the snuffing steam valves be tested every three months. This frequency of testing is required to keep the failures of snuffing steam system to once very 192 years for both furnaces.

Cracking Furnaces, Fault Tree No. 5

Fault Tree No. 5 considered failures of the snuffing steam system to an open position. Snuffing steam in an operating furnace causes an "all fires out" condition which places a demand on the shut down system. Overall FDT of the "all fires out" alarm, PLC I/O, and the 2 of 2 pilot

gas block valves is 0.0057 including bypass time. (See Fault Tree Support for details on FDT calculations.)

Top event for this situation is excess gas in furnace without any fire which itself does not lead to an explosion; however, if an igniter were pushed in this situation, a significant explosion would result depending on the quantity of gas built up in the furnace. As recommended in the Pec-Tri Dowtherm Heater Report, when snuffing steam valve position switches are sensed in the open position, a furnace shut down should be initiated to stop fuel gas flow. Once the shut down has been initiated, the accidental pushing of an igniter is not possible because of the start up sequence required by the flame management system.

Cracking Furnaces, Fault Tree No. 6

Fault Tree No. 6 deals with cold furnace start up and rate changes. The system, as designed, requires the operator to establish crude EDC feed prior to increasing the furnace firing rate. Also significant rate changes of the feed requires operator interface to prevent tube rupture from over firing. During cold start ups a loss of flow as determined by the two out of three inputs of the two furnace feed flows and one tube metal temperature per pass cannot cause a shut down because the two flows are bypassed prior to their respective values being satisfied. As a result of startup bypass, the shut down system can only be armed by the tube metal temperature. As a result, tube rupture from over firing and a resultant fire in the furnace occurs every 13.9 years.

It is recommended during startup that the shut down system for loss of flow condition be a one of three using tube metal temperature, high process outlet, and high bridgwall temperature. Revised hazard rates

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for both furnaces during start up and rate changes are reduced from once every 13.9 years to once every 2000 years. This one of three shut down on loss of flow condition should apply during the decoking phase also, although hazard rates for this phase have not been determined this time.

Dowtherm Heater, Fault Tree No. 1

Fault Tree No. 1 on the Dowtherm heater looks into the situation where the heater is double blocked, the low flow shut down fails to cause a shut down and the relief valve fails to relieve. As expected, the occurrence of tube ruptures or flange leaks is very low, once every 968 years. Number of occurrences of "seized closed" safety valves was taken from the ICI Failure Rate Data Book; however, these values do take into account the peculiarity of a frozen safety valve inlet, which is a characteristic of the fluid to be relieved. Dowtherm[®] A and Therminol[®] VP fall into these classifications of fluids. The following recommendations are made on the relief valve installation system, whose most common reason for failing would be freezing:

1. Install a local "skin temperature" sensor beneath the insulation on PSV-9-509 inlet flange.
2. On the steam trap that controls condensate removal on the PSV inlet piping, use a liquid crystal temperature sensor that visually signifies a working or plugged trap by changes in color.
3. It should be standard operating practice prior to start up to check the condition of the steam trap on safety valve inlet piping to insure proper operation.
4. An alternate to steps 1 - 3 would be to use a heat transfer

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media whose freezing point is below the lowest recorded temperature in the Lake Charles area, preferably below 0°F.

Dowtherm Heater, Fault Tree No. 2

Fault Tree No. 2 deals with the loss of Dowtherm flow via pump or the blockage of a single valve. The primary devices that provide a backup system for these situations are a low flow switch, high tube metal temperature, and high stack temperature.

The temperature loop TIC-9604 is not a backup system for a loss of flow condition since this primary device relies on flow to sense the bulk temperature of the process outlet of the heater. With a flow stoppage the thermocouple controlling operation of firing rate is outside the heater and therefore fails to a dangerous situation. Only these thermocouples within the heater provide a backup system to a flow stoppage demand.

Overall FDT, including PLC I/O and the three gas block valves, is 0.00405. (Refer to Fault Tree Support Data for details on FDT calculations.) The number of occurrences of Dowtherm carburization from over firing are once every 1013 years which includes operating steam time of ten percent.

It is recommended to alarm low Dowtherm flow at 750 GPM and to initiate a low flow shut down at 700 GPM. (Refer to Fault Tree Support information for details.)

Dowtherm Heater, Fault Tree No. 3

This fault tree has been voided as these demands have been included in Fault Tree No. 4.

Dowtherm Heater, Fault Tree No. 4

Fault Tree No. 4 considers a shut down situation initiated by a flammable vapor cloud. It is assumed that every vapor cloud reaches at least two of the six vapor detectors that surround the Dowtherm heater. As a result of 0.5 vapor clouds per year the number of major explosions is once every 6480 years.

Dowtherm Heater, Fault Tree No. 5

Fault Tree No. 5 investigates the number of Dowtherm carburization as a result of temperature loop TIC-9604 failing open. The backup systems for these demands are high tube metal temperature, high stack temperature, and high outlet temperature. The use of 0.001 as the fractional dead time for the three of three temperature sensors is based on common mode, since all of the primary devices are identical and do not provide system diversity. Total number of Dowtherm carburizations as a result of excess gas firing is once every 13,720 years which includes the operating stream factor.

Light and Heavy Stills, and Vinyl Storage Area

A Level III investigation into these areas revealed no occurrences of major/minor explosions or significant toxic gas releases. However, a toxic gas dispersion program was run to simulate the relieving of a safety valve in the vinyl storage area. As seen from the computer output titled VC01 in Appendix III, the release is summarized as a 100% probability of a category zero.

OHC Reactor and Liquid Phase Reactor Combined Vent System

The combined vent of the OHC and the liquid phase EDC reactor can become an explosive mixture when excess chlorine is present. Refer to

the ternary diagram in Appendix IV. Normally this vent system contains ethylene, trace quantities of HCL chlorinated hydrocarbons, and inserts which are not an explosive mixture. From the liquid phase ethylene dichloride reactor section (Unit II) Level III Reliability Study, the occurrences of high chlorine in the vent system was determined to be .00893 times per year. (Refer to Fault Trees Nos. 11A and 15A for details.)

Explosions once every 112 years as a result of high chlorine is anticipated for each excursion of excess chlorine because ethylene is always present in the vent.

The gas chromatograph backup system as defined in the OHC-Rx study, Fault Tree No. 11 and my letter dated May 15, 1980, titled Gas Chromatographic Analysis Backup Oxygen Analysis (Refer to Appendix IV), should be used to prevent explosions due to excess chlorine in the vent system. The fraction dead time of such a system is relatively high (0.05) but the low number of demands results in only one explosion every 2240 years due to excess chlorine in the combine OHC and liquid phase reactor vent system.

The following Table II summarizes the combined VCM II Expansion for toxic gas releases, minor explosions, and major explosions. When the Liquid Phase Reactor, Unit II, Report was completed, the excursions of excess chlorine were not included in the explosion category. Using the explosion diagram for ethylene, chlorine, and inerts shown in Appendix IV, it was agreed that when sufficient amounts of chlorine were present in an over chlorinated liquid phase reactor, a major explosion results which endangers the life of operating personnel and causes significant unit down time. Explosions resulting from excess chlorine are included in

the VCM II Unit Summary.

Only in Category 0 did the VCM II expansion meet the "as designed" criteria. All other categories of toxic gas releases, minor explosions, and major explosions exceeded the criteria. However, with the recommended proposals in this report as well as the OHC - Reactor Report, and the Liquid Phase EDC Reactor Report all criteria can be met.

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DISCUSSION AND RESULTS (Continued)

TABLE II
VCM II SUMMARY

<u>Events</u>	<u>As Designed</u>	<u>Proposed</u>	<u>Criteria</u>
I. Toxic Realeases			
Category III	0.8	18.2	15-30
Category II	0.39	5.5	2-5
Category I	0.4	7.4	0.5
Category 0	0.4	6.7	0.0192
II. Minor Explosions	1.01	101	5-10
III. Major Explosions	3.0	55.9	50-100

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RECOMMENDATIONS

EDC Cracking Furnaces

1. Install position switches on XV-A151 through A178. These new position switches must be proved closed prior to start up.
2. Install solenoid dump valve on HV-3834 to make venting of this valve automatic instead of operator dependent.
3. Alarm crude EDC cracking flow at design minus 20%. This would allow for turn down if the alarm condition was determined from the control set point and not a predetermined quality. The shut down value should be determined from the set point also.
4. Initiate a furnace shut down when the flow is 33% below set point.
5. Alarm radiant Tube Metal Temperature at 1400°F.
6. Initiate a furnace shut down when TMT exceeds 1500°F.
7. If snuffing steam valve position switches are sensed in the open position, a furnace shut down is initiated.
8. During start up bypass, the shut down of the furnace should be a one of three on:
 - a. Tube metal temperature, 1500°F
 - b. Outlet temperature, 1200°F
 - c. Bridgewall temperature, 1750°F.

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Once the flow shut down values have been satisfied for 30 seconds, the low flow shut down reverts to a two of three based on two flows and one TMT.

9. Prior to furnace start up, determine that each flame detector discriminates on its particular pilot or burner. In multiple burner systems each detector must be positioned so its line of sight does not intercept

flames from other burners. Flame discrimination can be adjusted by reducing sensitivity until the flame relay only responds to its pilot or burner and not adjacent flames.

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TEST REQUIREMENTS

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EDC Cracking Furnaces

1. The protective shut down function for the furnaces should be proof tested once per month unless a scheduled shut down provides the proof test requirement for that shut down function.

2. Once per month compare furnace thermowells with dual thermocouples and note deviation. ANY thermocouple not meeting manufacturer specification should be replaced.

3. Zero and span orifice run and vortex shedding meter on furnace feed twice per year. Verify alarm and shut down valves each month. Compare vortex and orifice meter reading and note deviations. Deviations greater than five percent should be remedied.

4. Compare furnace inlet pressure readings once per month and note deviations. Significant deviations should mean differences in coking rates on the parallel furnace tube runs. Improper firing patterns should be suspected.

5. Test the snuffing steam system every three months.

6. Test all safety relief valves at least once per year.

7. Test vapor detectors prior to each scheduled start up but no less than twelve times per year.

8. Visually inspect and verify all position switches on all gas valves prior to each scheduled start up.

Dowtherm Heater

1. Test relief valves prior to each scheduled start up (minimum, twice per year).

2. Test vapor detector with combustible gas prior to each scheduled

start up. Verify operation of gas and deluge valves.

3. The shut down functions controlled by the vapor detector should be tested prior to each scheduled start up.

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CONCLUSION

If the aforementioned recommendations in this report and the OHC and Liquid Phase EDC Reactor reports are accepted and become standard operating practice, the toxic gas criteria as well as the explosion criteria can be met for the entire vinyl chloride monomer expansion.

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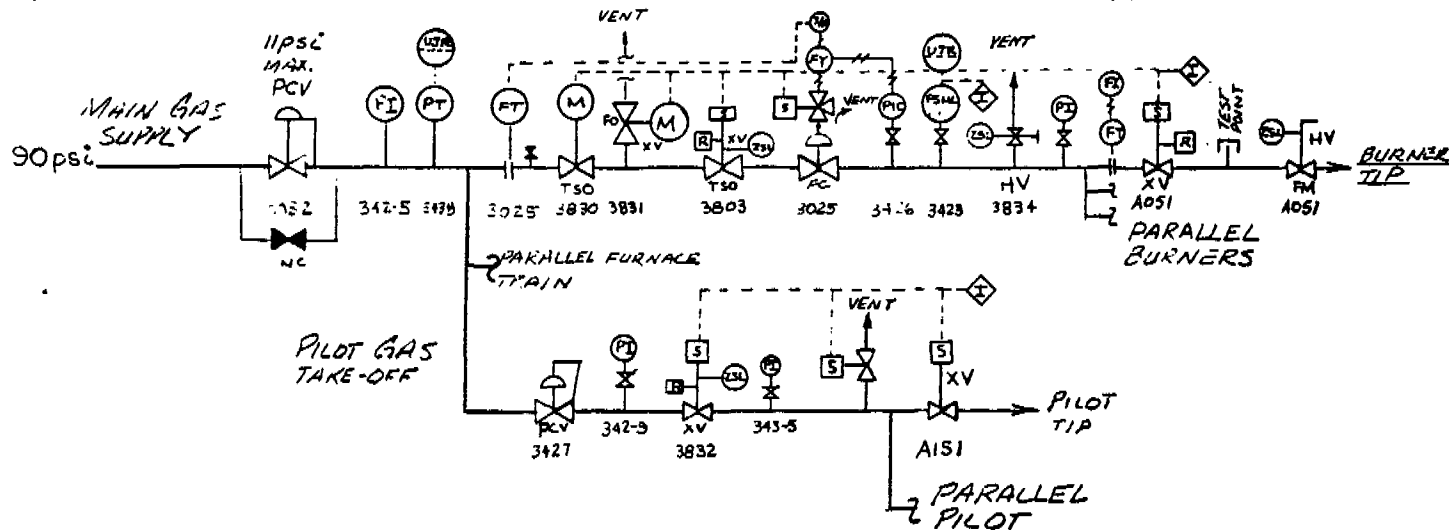
APPENDIX I

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5.0

SL 012046

Client PPG-LAKE CHARLES, LA. Ref. D-13-MP-3,20 Date 8/11/80
 Job VLM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject EDS CRACKING FURNACES - GAS SUPPLY Checked By BAVIRNIO



MAIN AND PILOT GAS CONTROLS - AS DESIGNED

TESTING OF THE AS DESIGNED SYSTEM
 WOULD OCCUR ON THE TWO SCHEDULED
 SHUTDOWNS (T=0.5 YEARS).

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Client PPG-LAKE CHARLES, LA Ref. _____ Date 5/19/80
 Job ULMATE- RELIABILITY STUDY, LEVEL III By PAKELLEY
 Subject CRACKIN FURNACE INST. FAILURE RATES Checked By BAVIRNIG

ICI REPORT MD 19128/1 COPY NO 60 (#5)

TIME DELAY RELAY - INDUSTRIAL USE

$$\frac{3.3 \text{ FAULTS}}{10^6 \text{ hr}} \times \frac{8760 \text{ hr}}{1 \text{ yr}} = 0.0289 \frac{\text{FAULT}}{\text{yr}}$$

$$\text{DANGEROUS \& FAST} \times 1/9 = 0.003 \text{ FAILURES/yr}$$

VALVE POSITION SWITCH - USE IND. LEVEL SWITCH DATA

$$\text{TOTAL, } \theta = 0.053 / \text{yr}$$

$$\text{DANGEROUS (FAST \& SLOW)} \times 1/3 = 0.018 \text{ FAILURES/yr}$$

SHUTOFF VALVE IN GAS SERVICE - SLAM SHUT

$$\theta = 0.021 \text{ f/yr ; REMAINING OPEN}$$

FLAME FAILURE DETECTOR - 1.69 f/yr

$$\text{DANGEROUS \& FAST} = 0.17 / \text{yr (NO FLAME BUT KEEPS GAS VALVE SHUT)}$$

IGNITERS - USE 0.10 AS FDT . IN OTHER WORDS,
 FOR EVERY 100 DEMANDS ON AN IGNITER
 (WITH GAS AVAILABLE) A FLAME DOES NOT
 RESULT.

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Client PPG-LAKE CHARLES, LA. Ref. _____ Date 9/19/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACES - SHUTDOWN SYSTEM DEMAND Checked By BA VERNIG

BASIS: 1. USE A TOTAL OF 6 SHUTDOWNS STARTUPS
PER YEAR OF WHICH ~ 1/3 ARE SPURIOUS SHUTDOWNS

2. SPURIOUS SHUTDOWNS BY SHUTDOWN SYSTEM
OF 1.7 PER YEAR

3. SHUTDOWNS (OTHER THAN SPURIOUS)

a. 0.5/yr by VAPOR CLOUD.

b. 1.5/yr ELECTRICAL FAILURES.

c. 0.3/yr LOSS OF CRUDE EDC FLOW

d. 2.0/yr SCHEDULED SHUTDOWNS

4.3/yr NONSPURIOUS SHUTDOWNS

1.7/yr SPURIOUS SHUTDOWNS (PRIMARILY ESL FAILURES)

6.0/yr TOTAL SHUTDOWNS

TOP EVENTS

1. IF FURNACE TEMPERATURE SENSOR (PLC-3621)
FAILS, IT IS POSSIBLE TO START A "COLD"
FURNACE WITHOUT 5 MINUTE PURGE TIME.

2. A FLAME EXISTING IN THE FURNACE AFTER A
VAPOR DETECTOR INITIATED SHUTDOWN

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Client PPG-LAKE CHARLES, LA. Ref. TREE ID. #1 Date 8/20/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject CRACKING FURNACES - PILOT GAS RATE TO FURNACE Checked By BAVIRNIG

1" LINE @ 5 psig NAT. GAS. SCH 80

$$ID. = .957 \quad \dot{W}_m = 1016/hr$$

$$P = 5 + 14.7 = 19.7$$

$$\Delta P = 5 \text{ psi} \times 2.31 \frac{\text{FT}}{\text{psi}} \times \frac{12 \text{ IN}}{\text{FT}} = 138.6 \text{ IN H}_2\text{O}$$

$$C_p/C_v = 1.3$$

$$P_{STD} = \frac{15.042}{0.7302 (520)} = 0.0422 \frac{\text{lb}}{\text{FT}^3} @ 60^\circ \text{F}, 14.7 \text{ psig}$$

$$P_{20 \text{ F} + 5 \text{ psig}} = \frac{23.67 \text{ FT}^3}{13} \times \frac{540}{520} \times \frac{19.7}{14.7} = 18.34 \frac{\text{FT}^3}{\text{LB}} \cdot 0.0422 \frac{\text{lb}}{\text{FT}^3}$$

$$d_o = 1/16" \quad \mu = 0.013$$

$$\text{PILOT GAS FLOW} = 2.17 \text{ lbs/hr or } \underline{2.17}$$

$$\text{PILOT GAS} = 51.42 \frac{\text{FT}^3}{\text{HR}} \cdot 0.0422$$

DISCUSSIONS ON 8/21/80 WITH A JOHN

ZINK REP. INDICATES THAT A TYPE J PILOT ORIFICE WITH 3 to 5 psig ON THE INLET WILL PASS 63 to 85 SCFH OF NATURAL GAS. USING THE HIGH RANGE OF GAS FLOW AND AN AVERAGE DURATION OF 15 MINUTES PRIOR TO IGNITION, APPROXIMATELY 21 STD. FT³ OF GAS WOULD ESCAPE INTO THE FURNACE CHAMBER

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Client PPG-LAKE CHARLES, LA. Ref. _____ Date 8/28/80
 Job UNIT-RELIABILITY STUDY, LEVEL III By P.A. KELLEY
 Subject CRACKING FURNACE-EXPLOSION CALC'S. Checked By BA VERNIG

OVERALL FURNACE DIMENSIONS

	<u>VOLUME - FT³</u>
RADIANT SECTION - 34 X 16 X 26 =	14144
CONVECTION SECTION - (34 X 4 X 6).5 =	408
	14552
	SAY <u>15000 FT³</u>

VENT AREA

	<u>AREA - FT²</u>
STACK - 4'-3" ID	14.2
EXPLOSION DOORS - 6-4 FT ²	24.0

TOTAL 38.2 FT²

$$\text{VENT AREA RATIO} = \frac{38.2 \text{ FT}^2 (100)}{15000 \text{ FT}^3}$$

$$\text{RATIO} = .25 \text{ FT}^2 / 100 \text{ FT}^3$$

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Client PPG - LAKE CHARLES, LA. Ref. _____ Date 8/29/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By P. A. KELLEY
 Subject CRACKING FURNACE - EXPLOSION CALC'S. Checked By B. A. VIRNIG

DETERMINE MAX. PRESSURE RISE w/ $5 \text{ FT}^2 / 100 \text{ FT}^3$

INITIAL = SET = 1.0 psig

INIT. PRESS	RUPTURE PRESS	EXP. PRESS
15	50	80
15	100	125
45	50	160
45	100	210

$$\frac{49}{99} = \frac{80 - x}{125 - x}; x = 35.20$$

$$\frac{49}{99} = \frac{160 - x}{210 - x}; x = 109.3$$

$$\frac{15-1}{45-1} = \frac{35.2-x}{109.3-x}$$

$x = 0.9 \text{ psi}$ EXP. PRESSURE

DET. MAX. PRESSURE RISE w/ $3 \text{ FT}^2 / 100 \text{ FT}^3$

INIT.	RUPTURE	EXP.
15	50	110
15	100	145
45	50	265
45	100	300

$$.495 = \frac{110 - x}{144 - x}; x = 75.7$$

$$.495 = \frac{265 - x}{293 - x}; x = 230.7$$

$$.318 = \frac{75.7 - x}{230.7 - x}$$

$x = 3.4 \text{ psi}$ EXP. PRESSURE

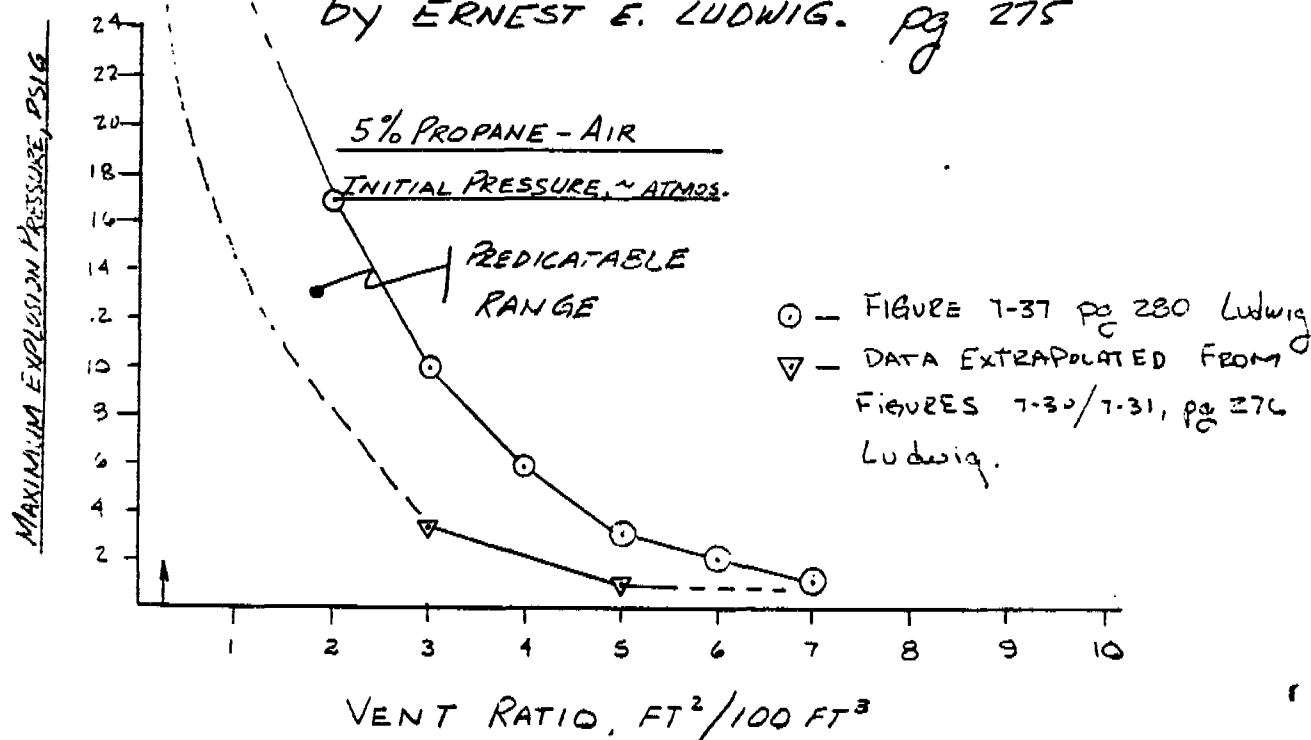
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Client PPG - LAKE CHARLES, LA. Ref. _____ Date 7/28/80

Job VCM II - RELIABILITY STUDY, LEVEL III By P. KELLEY

Subject CRACKING FURNACE - EXPLOSION CALCULATIONS Checked By B.A. VERNIG

SOURCE DATA: APPLIED PROCESS DESIGN FOR CHEMICAL AND PETROCHEMICAL PLANTS / VOL. I
BY ERNEST E. LUDWIG. pg 275



WITH A DESIGN VENT OF 0.25 FT²/100 FT³
 A MAX. EXPLOSION PRESSURE OF 21-30 PSIG CAN
 BE REALIZED WITH THE TOTAL VOLUME FILLED
 WITH AN EXPLOSIVE MIXTURE.

IF 21 STD FT³ OF NATURAL GAS DILUTED
 TO 7.5 VOLUME PERCENT, APPROXIMATELY 280
 FT³ OF AN EXPLOSIVE MIXTURE IS PRESENT.

SINCE THE FURNACE'S RADIANT SECTION IS
 DIVIDED BY A BRISSEWALL THE VOLUME
 CONTAINING THE EXPLOSIVE MIXTURE IS
 APPROXIMATELY 7500 FT³

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SL 012053

Client PPG-LAKE CHARLES, LA. Ref. _____ Date 9/2/80
Job VCM II- RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACES - EXPLOSION CALC'S Checked By B.A. VERNIB

TO DETERMINE THE PRESSURE RISE ASSOCIATED WITH AN EXPLOSION OF 280 FT³ OF AIR/NATURAL GAS IN 7500 FT³, IT WAS ASSUMED THAT THE RISE IN PRESSURE IS PROPORTIONAL TO THE AMOUNT OF EXPLOSIVE MIXTURE.

$$\text{EXPLOSION PRESSURE} = \frac{280 \text{ FT}^3}{7500 \text{ FT}^3} \times 30 \text{ psig}$$

$$\text{EXP. PRESSURE} = 1.1 \text{ psig}$$

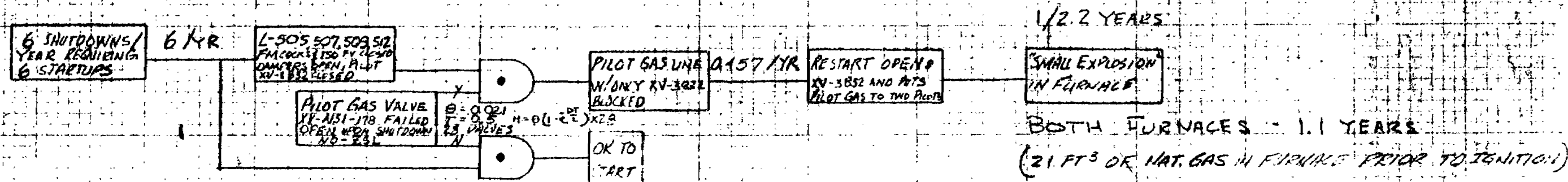
CATEGORIZE THIS TOP EVENT AS A SMALL EXPLOSION CAPABLE OF VERY MINOR DAMAGE SUCH AS DISLODGING EXPLOSION DECKS, BURNERS AND/OR PILOT TIPS, AND DAMPERS. THE EXPLOSION PRESSURE SHOULD NOT CAUSE STRUCTURAL DAMAGE TO THE FIRE BOX OR TUBES BUT MAY DISLodge SMALL PART OF REFRACTORY

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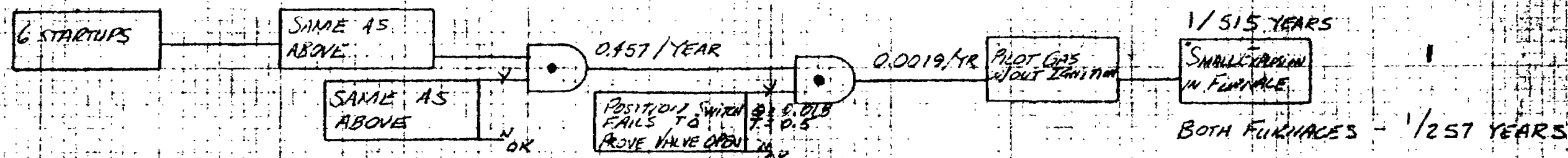
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RECOMMENDATION:

1. INSTALL POSITION SWITCHES ON XV-A151 THROUGH A178. THESE POSITION SWITCHES MUST BE PROVED CLOSED PRIOR TO STARTUP.

REVISED HAZARD RATES W/ NEW POSITION SWITCHES



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SL 012055

EDC CRACKING FURNACES #1
FAULT TREE ID. EXCEEDS GAS IN FURNACE - STARTUP
BY AND DATE: PA KELLEY 8/20/80
PA KELLEY

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Job No. 79.57

P. O. Box 3971 Beaumont, Texas 77704 713-842-2417

Client PPS-LAKE CHARLES, LA Ref. _____ Date 3/27/90
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACES - FDT OF PILOT/MAIN GAS VALVES Checked By BA VERNIG

PILOT GAS SYSTEM - DWG. D-13-MP-20,21 REV 4.

- TWO SOLENOID CONTROLLED BLOCK VALVES
- ONE SOLENOID CONTROLLED VENT VALVE
- ONLY THE UPSTREAM BLOCK VALVE HAS A POSITION INDICATOR.

HAZARD - BOTH BLOCK VALVES FAIL OPEN ON SHUTDOWN

FIRST VALVE $\theta = 0.021$ SECOND VALVE (28 VALVES) $\theta = 0.021$
 $T = 0.5$ $T = 0.5$

$$FDT = \frac{\theta T}{2} = 0.00525 \quad FDT = 28 \left(\frac{\theta T}{2} \right) = 0.147$$

FDT OF BOTH VALVES FAILING OPEN IS

$$FDT = \frac{4}{3} (FDT^2) = \frac{4}{3} (0.00525)(0.147) = 0.00102$$

MAIN GAS SYSTEM

- ONE MOTOR CONTROLLED TIGHT SHUTOFF VALVE
- " SOLENOID " " " w/ZSL
- " " " FLOW CONTROL BLOCK VALVE
- " " " BLOCK VALVE (28 VALVES)
- " MANUAL SUPERVISORY COCK VALVE w/ZSL
- " MOTOR CONTROLLED VENT VALVE
- " MANUAL VENT VALVE w/ZSL

HAZARD - FOUR BLOCK VALVES FAIL OPEN ON SHUTDOWN

$\theta = 0.021$ ONE VALVE IS PARALLELED
 $T = 0.5$

$$FDT = \frac{\theta T}{2} ; FDT = \frac{16}{4} (FDT)^2$$

$$FDT = 0.00525 \quad FDT = 6.3 \times 10^{-6}$$

SL 012056

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 9/11/80
 Job UM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject CRACKING FURNACE - GAS SUPPLY REVISIONS Checked By DA VERNIG

DETERMINE FDT OF MAIN GAS WITHOUT
XV-3803 AND WITH FV-3025 BYPASS.

ASSUME THAT BYPASS AROUND FV-3025
 IS USED 2 TIMES PER YEAR FOR
 16 HOURS OR FOR $\frac{2 \times 16}{8760} (100) 0.4\%$
 OF THE TIME. USE 1% TO DETERMINE
 EFFECTS ON THE FURNACE

$$\theta = 0.021 / \text{YEAR}$$

$$T = 0.5$$

$$FDT_1 = \frac{0.021(0.5)}{2} = 0.00525 \text{ (1 VALVE)}$$

28 VALVES IN PARALLEL CUMMULATE FDT
 AT EACH BURNER OR 0.147

$$FDT_2 = \frac{4}{3} (0.00525)(0.147) = 0.00102$$

$$FDT_3 = 2 (0.00525)^2 (0.147) = 8.1 \times 10^{-6}$$

$$FDT_4 = 16/5 (0.00525)^3 (0.147) = 6.81 \times 10^{-8}$$

$$\text{OVERALL FDT} = (0.01) 8.1 \times 10^{-6} + (0.99) 0.00102$$

$$= 0.00102$$

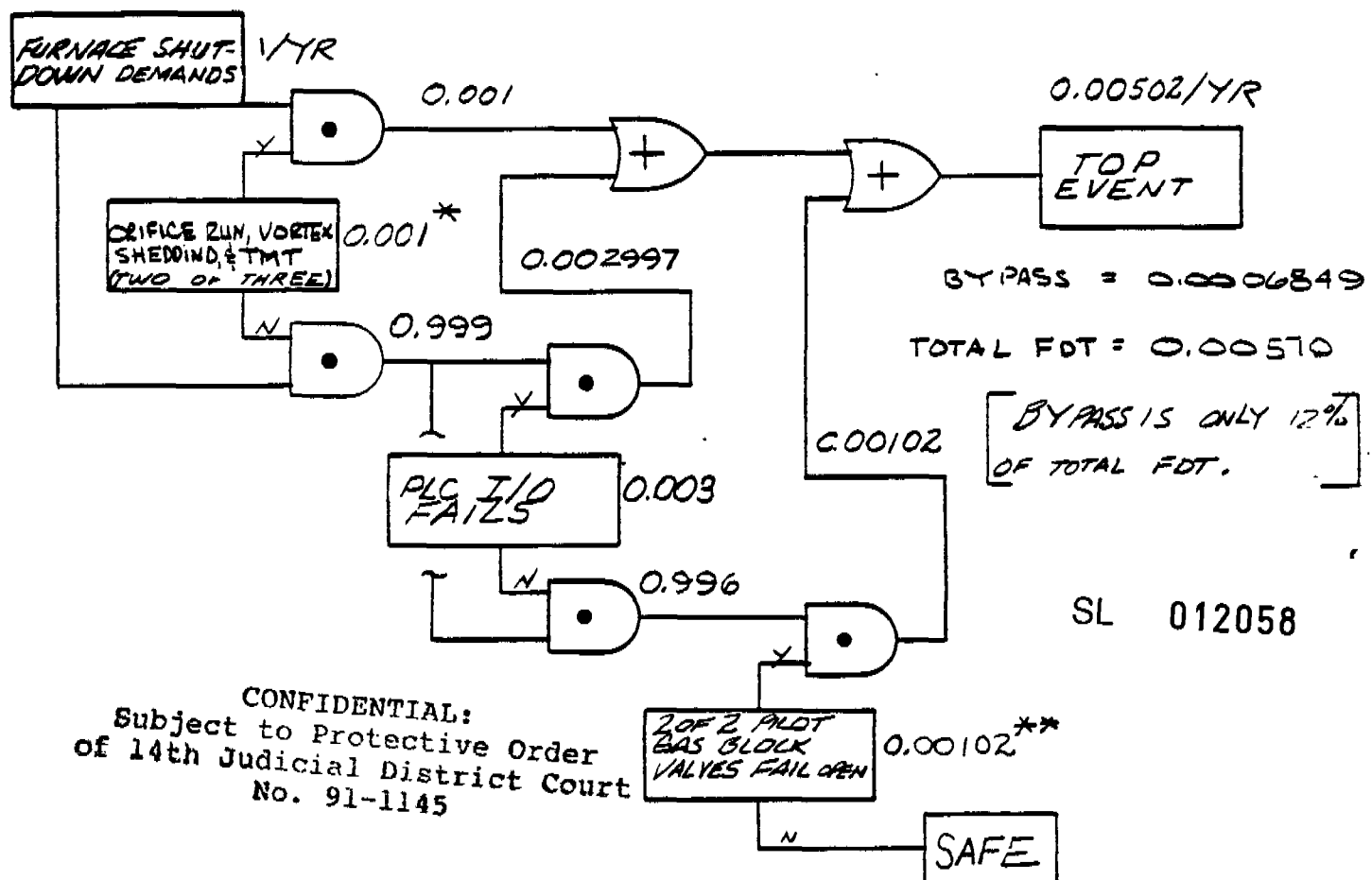
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SL 012057

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 8/27/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACE - FDT OF SHUTDOWN SYSTEM Checked By BA VIRNIG

OVERALL FDT OF FURNACE SHUTDOWN SYSTEM



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BYPASS - BOTH FLOW TRANSMITTER BYPASSED FOR ONE HOUR ON STARTUPS - $6/8760 \text{ hr} = 0.000685$

** THE CONTRIBUTION TO THE FDT BY THE FOUR AUTOMATIC BLOCK VALVES IN THE MAIN NATURAL GAS BURNER LINE IS ONLY 6.81×10^{-8} AND THEREFORE WAS NEGLECTED.

* REFER TO FAULT #9 LP-EDC REACTOR LEVEL III RELIABILITY STUDY. A 2 OF 2 FLOW TRANSMITTERS (ORIFICE AND VORTEX SHEDDING METER) HAS AN OVERALL FDT OF 0.001. THE ADDED TMT WOULD EFFECTIVELY REDUCE FDT

Client PP-1 - LAKE CHARLES, LA. Ref. _____ Date 9/11/80
Job VOLUME RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACE - GAS SUPPLY REVISIONS Checked By BA VERNIG

REVISIONS TO THE MAIN GAS SUPPLY LINE TO THE BURNERS WERE CONFIRMED TO ME BY W. L. OGLESBY ON 9/10/80.

1. ADD A BYPASS VALVE AROUND FLOW VALVE 3025.
2. REMOVE BLEND. & OPERATED TIGHT SHUTOFF 3803

THE OVERALL FDT OF THE FURNACE SHUTDOWN SYSTEM DOES NOT CHANGE SINCE THE "WEAK-LINK" IN THE SYSTEM IS THE PILOT GAS LINE. IN THE PILOT GAS LINE ONLY 2 OF 2 VALVES MUST FAIL TO REACH THE TOP EVENT.

FAILURE OF FOUR VALVES IN THE OPEN POSITION OF ON THE ORDER OF MAGNITUDE OF 10^{-9} . BY REMOVING ONE OF THE TSO VALVES AND INSTALLING A BYPASS ON FV-3025 THE OVERALL FDT OF THE MAIN BURNER LINE IS INCREASED; HOWEVER IT IS NOT AS LARGE AS THE PILOT GAS LINE.

SL 012059

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Job No. 19.57

Client PPG- LAKE CHARLES, LA. Ref. _____ Date 8/8/80
Job VLM II- RELIABILITY STUDY, LEVEL III By P.A. KELLEY
Subject CRACKING FURNACE TUBE RUPTURE - PUMP DEADHEAD Checked By BA VERNIL

MAXIMUM DESIGN PRESSURE ON TUBE IS 350 psig
MINIMUM DESIGN PRESSURE ON TUBES IS DEADHEAD
AND IS 442 psig. DETERMINE MAWP ON TUBES
INCOLOY 800H - SB-407

ALLOWABLE STRESS @ 1150°F = 10,000 psi

CIRCUMFERENTIAL STRESS EQUATION

$$P_{\text{psig}} = \frac{SEt}{R + 0.6t} \quad E=1 \text{ SEAMLESS}$$

AVERAGE WALL THICKNESS 0.3125"
CORROSION ALLOWANCE 0.0625"
0.25 - INCH

$$P = \frac{10000(1)(0.25)}{3 + 0.6(0.25)}$$

$$P = 793.7 \text{ psi} \geq \text{MAX DESIGN PRESSURE}$$

A FEED PUMP "DEAD-ENDED" ON THE FURNACE
TUBE AND THE 350 PSI RELIEF VALVE FAILING
TO RELIEVE DO NOT CAUSE A TUBE RUPTURE.

A WALL THICKNESS OF 0.2660 INCHES IS REQUIRED TO
CONTAIN A PRESSURE OF 442 PSI.

SL 012060

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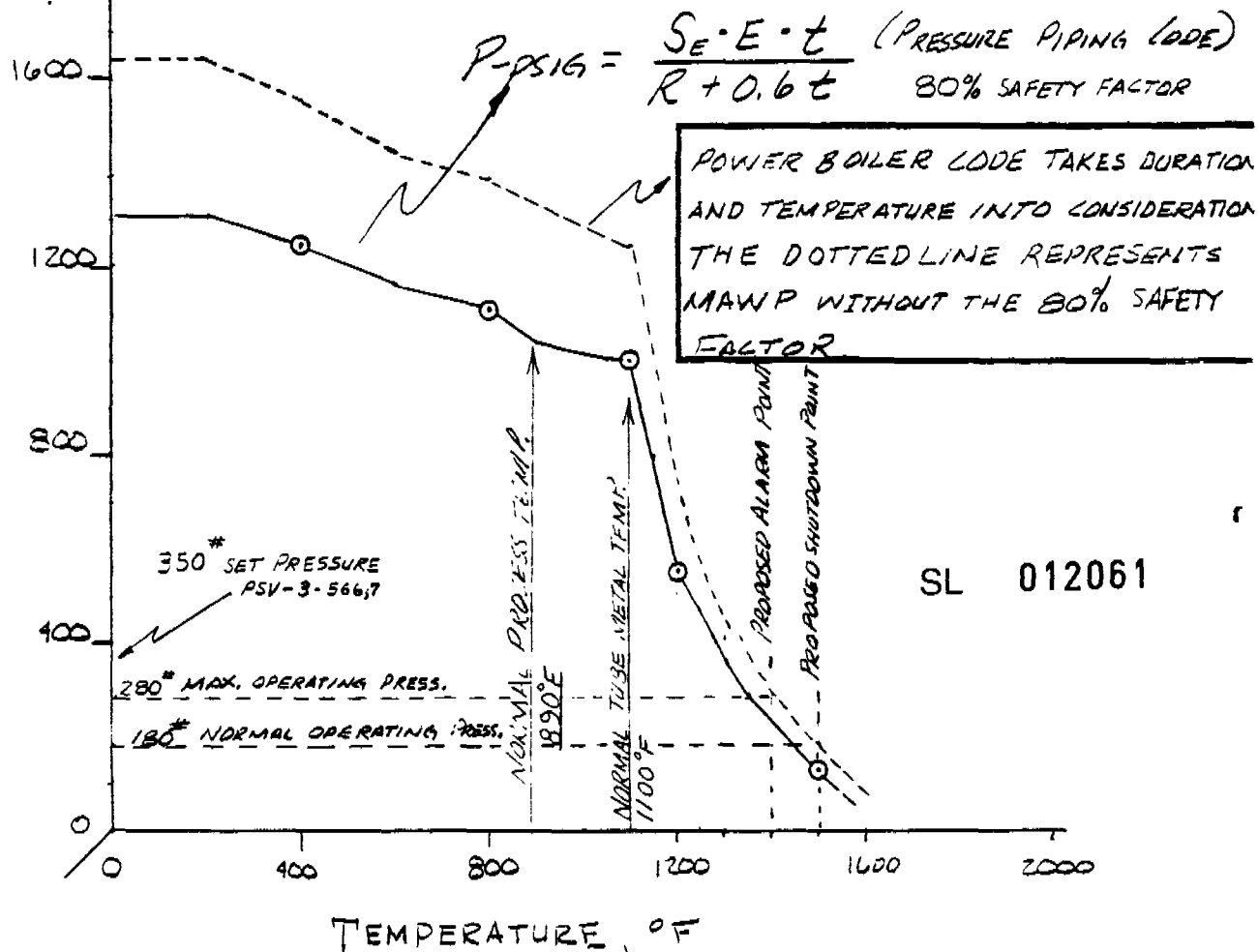
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Client PPG - LAKE CHARLES, LA. Ref. _____ Date 9/8/80
Job VCIA II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACE - INCOLY TUBES MAWP/TEMP. Checked By BAVI RN'6

WALL THICKNESS = 0.25" MATL. - INCOLOY 800H
LESS CORROSION ALLOWANCE
SEAMLESS PIPE
ASTM B-407

I. D. = 6.0"

MAXIMUM ALLOWABLE WORKING PRESSURE
- PSIG -



SL 012061

TEMP. °F	400	800	1000	1100	1200	1500
ASTM B-407 ALLOWABLE STRESS, SEPSI	15800	14000	12800	12700	7000	1700

SOURCE: AMERICAN NATIONAL STANDARD CODE FOR PRESSURE PIPING, ADDENDA TO CHEMICAL PLANT AND PETROLEUM REFINERY PIPING
ANSI B31.3-1976 - ANSI/ASME B31.3d-1980
DATE OF ISSUANCE: APRIL 15, 1980

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Job No. 79.57

Client PPG-LAKE CHARLES, LA. Ref. _____ Date 7/8/35
Job PLA II- RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACES - FLOW LOSS TO INCREASE Checked By BAVIRNIG
OUTLET TEMP TO 1000/1100°F

RADIANT CRACKING SECTION $Q = 26,950,000 \text{ BTU/hr}$
 $W = 90,400 \text{ lb/hr VAPOR}$
 $T_{IN} = 450^\circ\text{F}$
 $T_{OUT} = 890^\circ\text{F}$

SL 012062

$$Q = W C_p \Delta T$$

$$C_p = \frac{26,950,000 \frac{\text{BTU}}{\text{HR}}}{90400 \frac{\text{lb}}{\text{hr}} \times (890 - 450)^\circ\text{F}} = 0.677$$

$$W_{1000^\circ\text{F}} = \frac{26,950,000}{0.677 (1000 - 450)} = 72,378 \text{ lb/hr}$$

$$\Delta W_{1000} = \frac{72,378 (100)}{90,400} = \underline{\underline{80.0\%}}$$

$$W_{1100^\circ\text{F}} = \frac{26,950,000}{0.677 (1100 - 450)} = 61,243 \text{ lb/hr}$$

$$\Delta W_{1100} = \frac{61,243 (100)}{90,400} = \underline{\underline{67.7\%}}$$

1. ALARM CRUDE EDC FLOW AT $\pm 20\%$ DEVIATION
2. SHUTDOWN FURNACE AT $\pm 33.3\%$ DEVIATION
ON CRUDE EDC FLOW

DESIGN FLOW TO BOTH FURNACES IS 330 GAL/MIN
FLOW TO A SINGLE PASS = $330/4 = 82.5$

$$\text{ALARM FLOW} = 0.8 (82.5) = \underline{\underline{66 \text{ GPM}}}$$

$$\text{SHUT DOWN FLOW} = 0.67 (82.5) = \underline{\underline{55 \text{ GPM}}}$$

0.5/YEAR W/OK
DETECTOR AUTOMATIC

0.5/YEAR

W/OK PARTIAL GAS
VALVE XH409 FALCAY
NO 256

0.001
75 0.5
3 VALVES
OK

0.069/YR

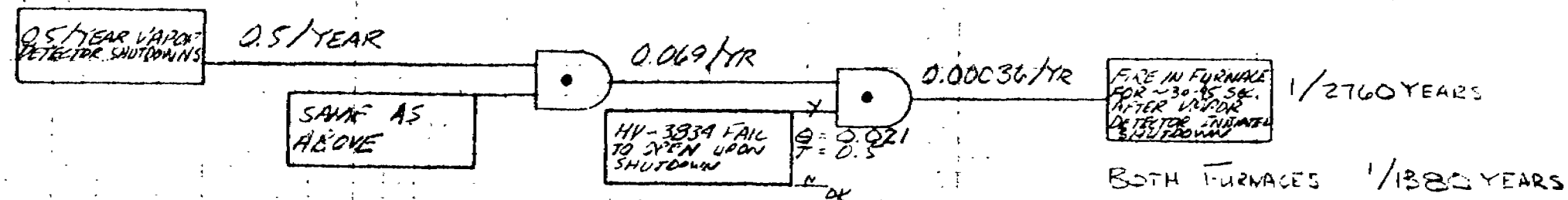
FIRE IN FURNACE
FOR ~ 30-45 SEC.
AFTER VALVE DEBLOW
LIMITED: HUIXWU

1/14.5 YEARS

BOTH FURNACES 1/7.2 YEARS

1. INSTALL SOLENOID DUMP VALVE ON HV-3834 TO MAKE VENTING OF THIS VALVE AUTOMATIC INSTEAD OPERATOR INITIATED OF A LOCAL VALVE.

REVISED HAZARD RATES W/ AUTOMATIC VENTING VALVE



EDC CRACKING FURNACES #2
FAULT TREE ID. FIRE IN FURNACE AFTER START SHUTDOWN
BY: DATE. PAUL A. KELLEY 5/25/80
B.A. KELLEY

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Job No. 7957

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 9/3/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACE - SNUFFING STEAM Checked By BA VIRNIG

SNUFFING STM - 3810/3811 (FAILS CLOSED)

LOOP COMPONENT TOTAL FAILURE

SOLENOID VALVE, HY 0.2

SL 012064

HAND VALVE, HV 0.2

$$G = 0.4 / \text{YR} \times \frac{2}{3} \text{ (DESIGN, FAST, \& SLOW)}$$

$$G = 0.27 / \text{YR}$$

FAILURE RATE OF BOTH VALVES IN THE CLOSED POSITION WHEN A DEMAND IS PLACED UPON THE SNUFFING STEAM IS THE MODE TO THE TOP EVENT.

DEMANDS ON THE SNUFFING FROM THE VAPOR DETECTORS IS 0.5 / YR. WITHOUT ANY TESTING ON THE SNUFFING SYSTEM, THE HAZARD RATE IS

$$H = \frac{G'D}{G'+D} \quad \text{WHERE } G' = \frac{2}{3} G \text{ FOR A 2 OF 2 SYSTEM FAILING}$$

$$G' = \frac{2}{3} (0.27) = 0.18$$

$$H = \frac{.18(.5)}{.18 + .5} = 0.132 / \text{YR} \text{ OR EVERY } 7.6 \text{ YEARS}$$

THIS IS TOO HIGH!

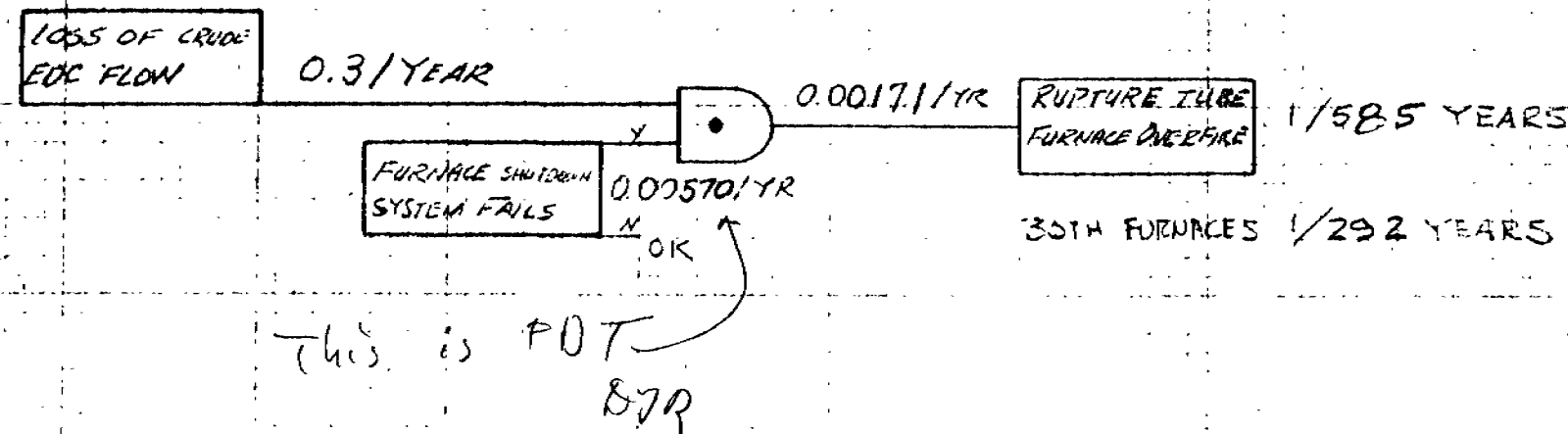
Use $T = 0.5$ $G = .27$ $D = .5$ $GT < .15$

$$H = \frac{G^n T^{(n-1)}}{T} (1 - e^{-\frac{GT}{T}})$$

$$H = .00428 / \text{Yr} \text{ OR ONCE IN } 233 \text{ YEARS}$$

if $T = 1/4$ $G = .27$ $D = .5$

$$H = 0.0011 / \text{Yr} \text{ OR ONCE IN } 906 \text{ YEARS}$$



RECOMMENDATIONS:

1. ALARM CRUDE EDC FLOW AT DESIGN $\pm 20\%$. (DESIGN FLOW = 82.5 GPM)
2. INITIATE FURNACE SHUTDOWN WHEN EDC FLOW IS DESIGN $\pm 33\%$.
3. ALARM RADIANT TUBE METAL TEMPERATURES 1400°F. DESIGN TMT IS 1100°F.
4. INITIATE FURNACE SHUTDOWN WHEN TMT IS 1500°F.

SL 012065

EDC TRACKING FURNACES #3

FAULT TREE ID: LOSS OF CRUDE EDC FLOW

BY AND DATE: PA KELLEY 9/2/80

BA VERNIL



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Page 1 of 2
Job No. 79.57

Client PPG - LAYS GRANULES, LA. Ref. _____ Date 9/3/80
Job LCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACE - SNUFFING STM FAILS OPEN Checked By BA VIRNIG

SNUFFING STEAM CONTROL LOOP - 3810

<u>LCM POVENT</u>	<u>TOTAL FAILURE</u> (FAILS CLOSED)
SOLENOID VALVE, HY	0.2
HAND VALVE, HV	0.2
	<u>0.4</u> X $\frac{1}{3}$ NON DESIGN

$$G = 0.13 \text{ / YEAR}$$

FAILURE OF EITHER VALVE 3810 OR 3811
PUTS STEAM INTO AN OPERATING FURNACE
WHICH COULD LEAD TO AN ALL "FIRES OUT"
CONDITION THIS SITUATION PUTS A DEMAND ONTO
THE FURNACE SHUTDOWN SYSTEM

ASSUME THAT AN OPERATOR ACCIDENTLY
TRIPS THE STEAM VALVES ONCE EVERY 20 YEARS
SNUFFING STEAM TRIP BUTTON IS PROTECTED BY
A COVER WHICH PREVENTS MOST ACCIDENTAL TRIPS.

SL 012066

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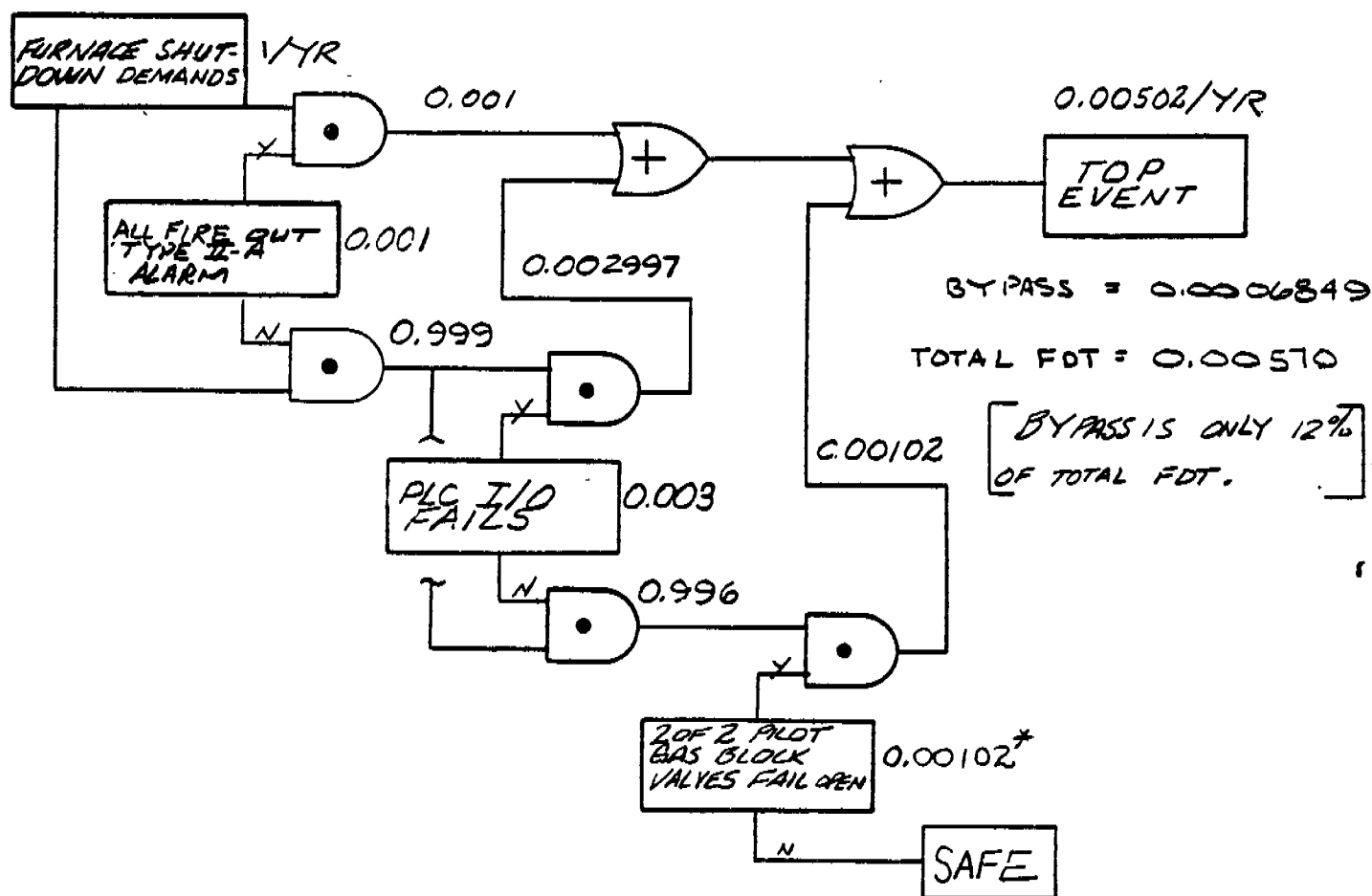
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Client PPG - LAKE CHARLES, LA. Ref. _____ Date 8/27/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACE - FDT OF SHUTDOWN SYSTEM Checked By BAVIRNIG

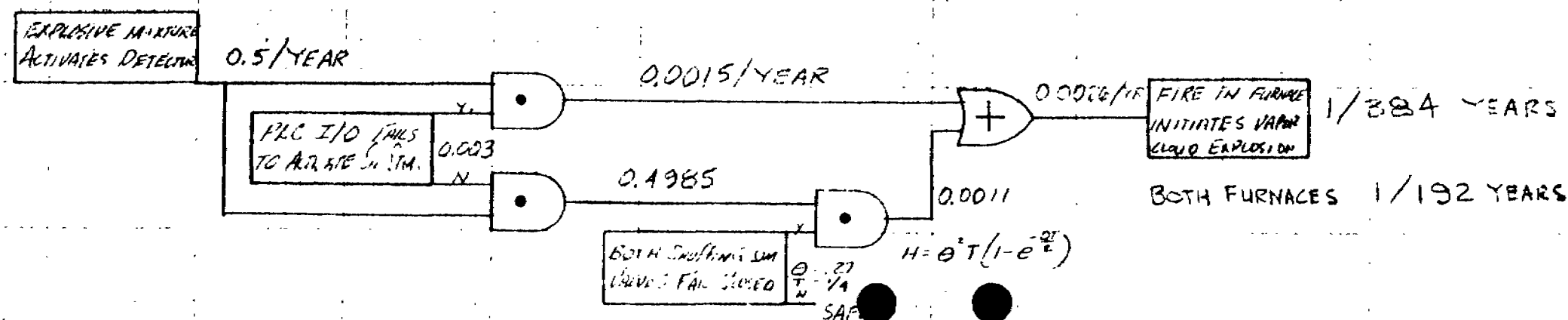
OVERALL FDT OF FURNACE SHUTDOWN SYSTEM



BYPASS - BOTH FLOW TRANSMITTER BYPASSED FOR ONE HOUR ON STARTUPS - $6/8760 \text{ hr} = 0.000685$

* THE CONTRIBUTION TO THE FDT BY THE FOUR AUTOMATIC BLOCK VALVES IN THE MAIN NATURAL GAS BURNER LINE IS ONLY 6.81×10^{-8} AND THEREFORE WAS NEGLECTED.

SL 012067

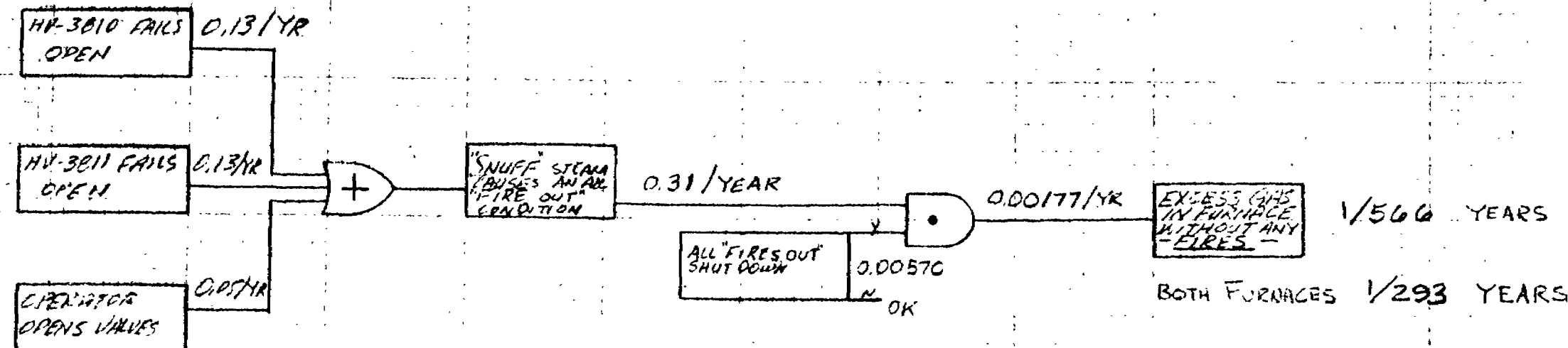


RECOMMENDATIONS:

1. TEST CLOSURE OF BOTH STEAM SNUFFING VALVES EVERY THREE(3) MONTHS.

SL 012068

EDC CRACKING FURNACES #4
FAULT TREE ID: FAILURE OF SNUFFING STEAM
BY AND DATE: PA KELLEY 9/4/80
BA VURMIG



NO RECOMMENDATIONS:

1. If snuffing steam valve position switches are sensed to be in the open position a shutdown is initiated.

REVISED HAZARD RATE

THE REVISED HAZARD RATE IS NIL SINCE POSING AN IGNITER WITH A SNUFFING STEAM VALVE POSITION SWITCH PROOVING OPEN IS NOT PERMITTED WITH THE FLAME MANAGEMENT SYSTEM ONCE A SHUT DOWN HAS OCCURED.

SL 012069

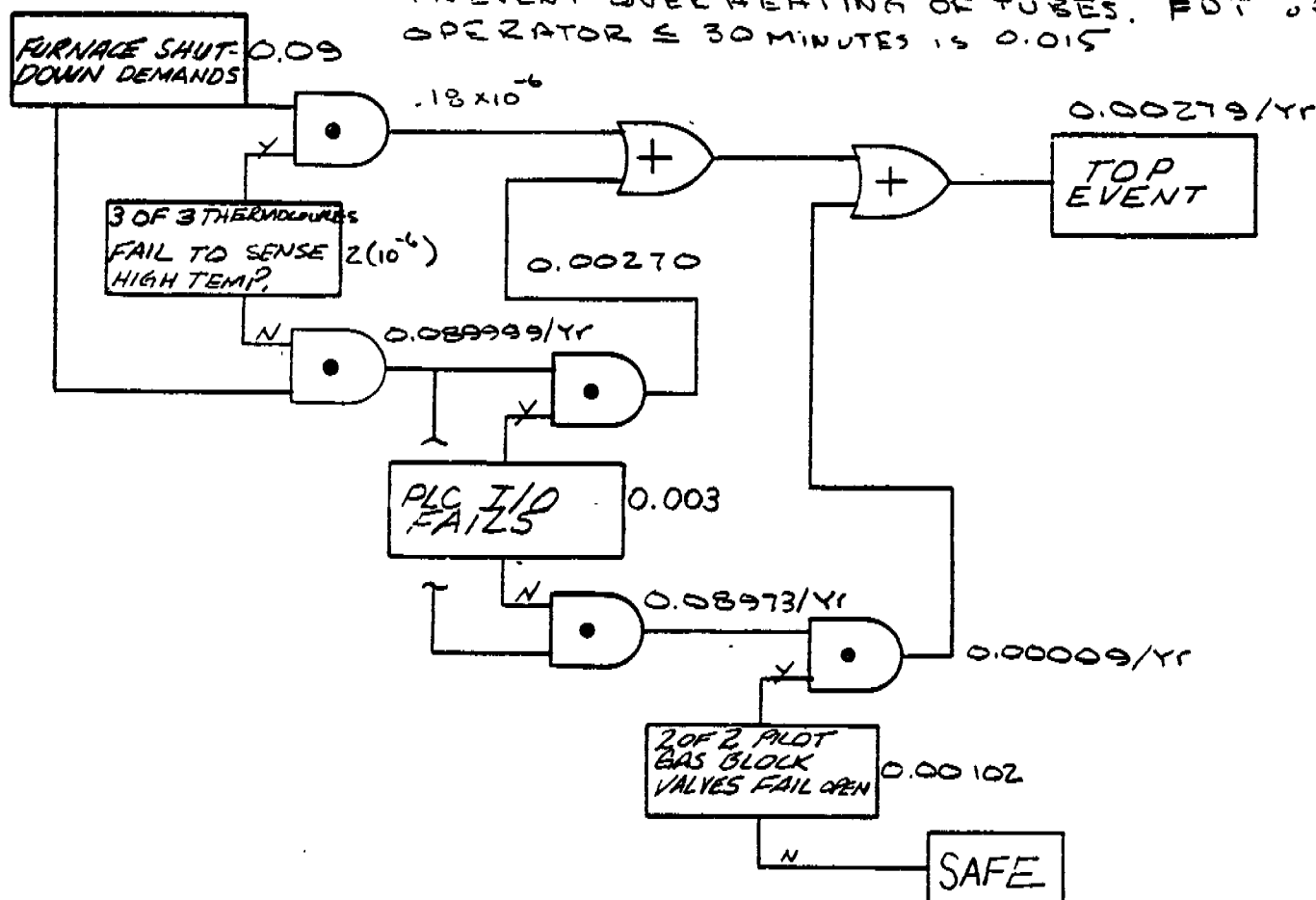
EDG CRACKING FURNACE # 5
FAULT TREE ID: SNUFFING STEAM FAILS OPEN
BY AND DATE: P.A. KELLEY 9/4/80
BA VERNIL

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 8/27/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject CRACKING FURNACE - COLD STARTUP & LARGE RATE CHANGES Checked By _____

1. 2 - COLD STARTUPS PER YEAR

2. 4 - 50% RATE REDUCTIONS

6 / YEAR SOP ACTION REQUIRED BY OPERATOR TO CUT FUEL GAS AS FEED IS REDUCED TO PREVENT OVER HEATING OF TUBES. FDT OF OPERATOR ≤ 30 MINUTES IS 0.015

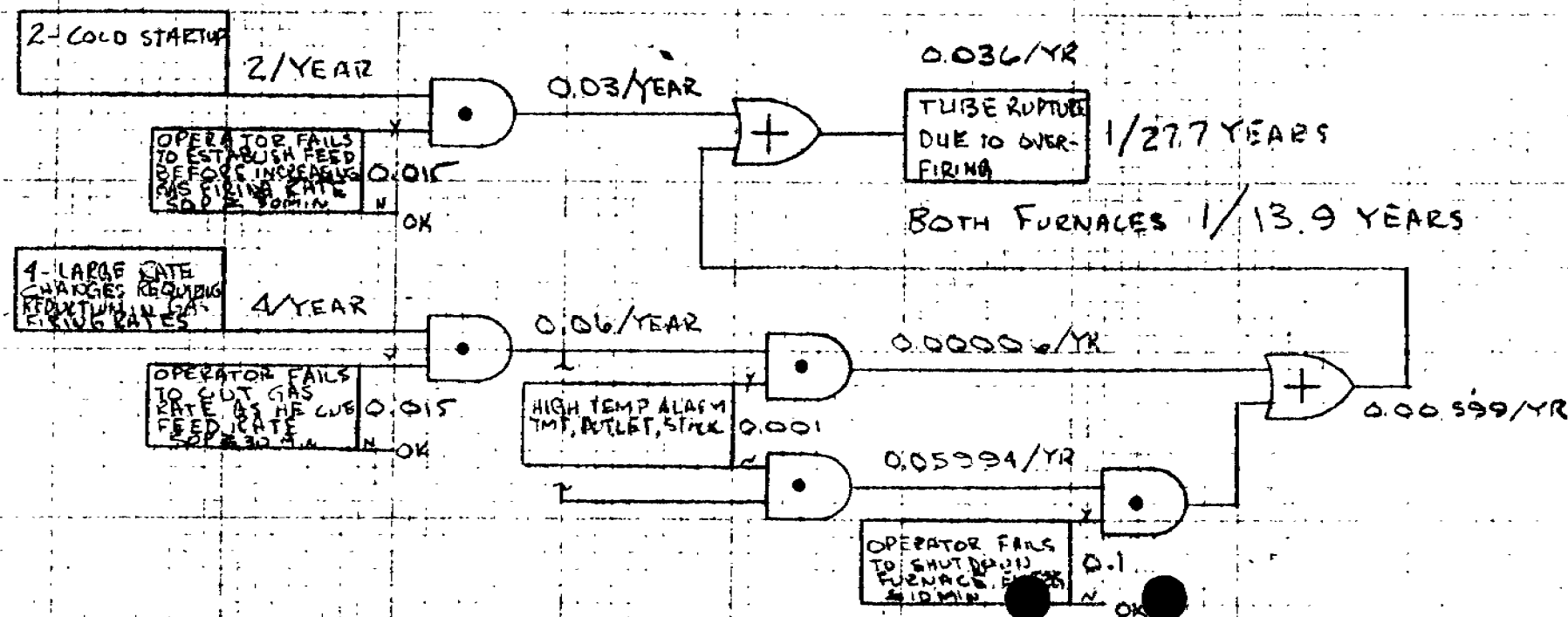


* THERMOCOUPLES FAIL TO DANGER, ICI DATA BOOK
 $\theta = 0.02$ w/ $T=1$ FDT $= \frac{\theta}{2} = \frac{0.02(1.0)}{2} = 0.01$ FDT₃ $= 2(0.01)^3 = 2 \times 10^{-6}$

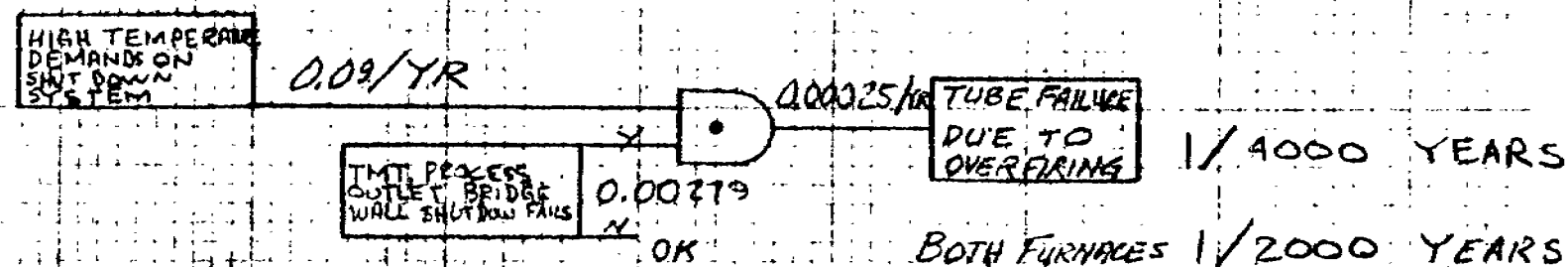
** THE CONTRIBUTION TO THE FDT BY THE FOUR AUTOMATIC BLOCK VALVES IN THE MAIN NATURAL GAS BURNER LINE IS ONLY 6.81×10^{-8} AND THEREFORE WAS NEGLECTED.

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REVISED HAZARD RATES



RECOMMENDATIONS:

1. DURING STARTUP BY PASS, THE SHUTDOWN SYSTEM SHOULD BE A ONE OF THREE ON
2. TUBE METAL TEMPERATURE (500°F)
3. HIGH PROCESS TEMPERATURE (1200°F)
4. HIGH BRIDGEWALL TEMPERATURE (1750°F)

SL 012071

EDC CRACKING FURNACES #6

FAULT TREE ID: TUBE FAILURE ON STARTUP

BY AND DATE: P.A. KELLEY 9/9/80
BAVIRNIA

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Page ____ Of ____
Job No. 7957

Client PPG-LAKE CHARLES, LA. Ref. _____ Date 9/22/80
Job VIOLATE RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject DOWTHERM A HEATER - PSV CALC'S Checked By BAVIRNIG

FIRING DUTY - 8.0 MMBTU/hr

HEAT OF VAPORIZATION of DOWTHERM A @ 760°F
92 BTU/lb

$$W = Q/L = 8,000,000 / 92 \\ = 86957 \text{ lb/hr}$$

SET PRESSURE = 150 PSIG

RELIEFING PRESSURE = 179.7 PSIA.

$$A = \frac{W \sqrt{T} \sqrt{Z}}{C K P \sqrt{M}} \\ = \frac{86957 \sqrt{1220} \sqrt{1}}{320 \times 0.975 \times (179.7) \sqrt{165}}$$

$$A = 4.22 \text{ IN}^2$$

NEXT LARGER ORIFICE IS "N" ORIFICE (4.34 IN²)
REQUIRES A 4" INLET AND 6" OUTLET FLANGES.

PSV AS DESIGNED IS AN "L" ORIFICE
WITH 2.853 IN². NOT SUFFICIENT!!

RECOMMEND INCREASING PSV CAPACITY
FROM AN "L" TO A "N" ORIFICE.

SL 012072

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Job No. 7957

Client PPG - LAKE CHARLES, LA. Ref. D-10-MP.4 REV.2 Date 9/19/90
Job WM II - RELIABILITY STUDY, LEVEL II By PA KELLEY
Subject DOWTHERM HEATER - SHUTDOWN DEMANDS Checked By BAVIRNIA

BASIS: 1. TWO SCHEDULED STARTUP PER YEAR PLUS
STARTUPS REQUIRED BY FOLLOWING SHUTDOWNS.
2. 0.5/YR VAPOR CLOUD INITIATED SHUTDOWN.
3. 1.5/YR LOCAL ELECTRICAL FAILURES.
4. 2.4/YR LOSS OF DOWTHERM FLOW
5. 0.6/YR SPURIOUS SHUTDOWNS (PRIMARYLY ESL
FAILURES)
8.0/YR - TOTAL - 100% STREAM FACTOR

STREAM FACTOR - OHC-REACTOR, 92%
- DOWTHERM (MINIMUM), 8%

PREVIOUS DOWTHERM HEATER STUDY USED AN ON-
STREAM FACTOR OF 17.9%..

FOR THIS STUDY, 10 % STREAM FACTOR WILL
BE USED. TEN PER CENT OF THE TOP EVENT
WILL BE TAKEN FOR EACH FAULT TREE ON
THE DOWTHERM HEATER SUMMARY SHEET.

ADJUSTED BASIS FOR STREAM FACTOR.

1. TWO SCHEDULED STARTUP PER YEAR PLUS
STARTUP REQUIRED BY FOLLOWING SHUTDOWNS.
2. 0.05/YR VAPOR CLOUD INITIATED SHUTDOWNS
3. 0.15/YR LOCAL ELECTRICAL FAILURES.
4. 0.25/YR LOSS OF DOWTHERM FLOW
5. 0.05/YR SPURIOUS SHUTDOWNS (PRIMARYLY ESL FAILURES)

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Page ____ Of ____

Job No. 1957

Client PRG - LAKE CHARLES, LA Ref. _____ Date 9/25/90
Job VIA II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject DOWTHERM HEATER - LOSS OF FLOW Checked By _____

DOWTHERM HEATER AUTOMATIC BLOCK VALVES HS-9160/9161

<u>COMPONENT</u>	<u>FAILURES</u>	<u>CHARGER - FAST & CLOSED</u>
HS	0.1	x 1/9
HY	0.1	x 1/9
HV (Auto 20 min)	0.1	x 1/9

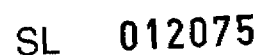
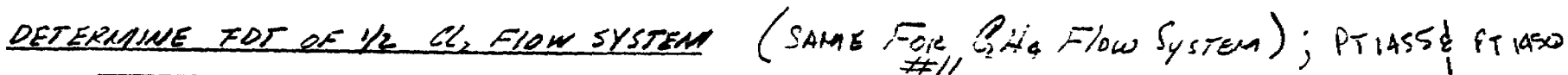
NON-REVEALED FAST CLOSED = 0.044/YR DURING
NORMAL OPERATION

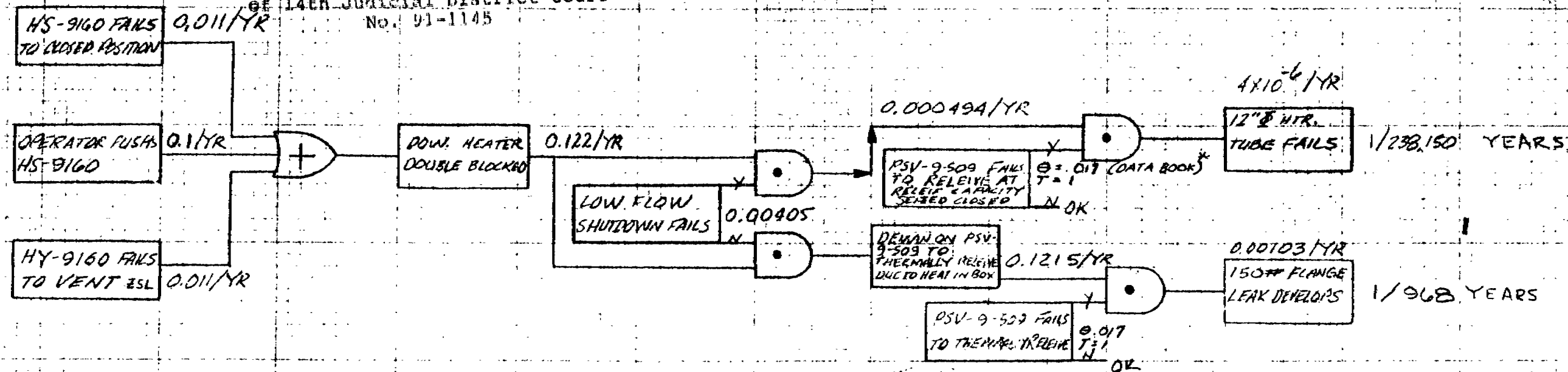
TEMPERATURE ACTIVATES HS-9160 0.10/YR
DURING OPERATION OF HEATER

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No. 91-1145

SL 012074

No. 51543





* ON FAILURE RATE DATA FOR RELIEF VALVES, NO FAILURE OF RELIEF VALVES WAS TAKEN FOR FREEZING ON INLET PIPING SO THE REVISED SOP MUST BE ADOPTED TO INSURE RELIEF VALVE PERFORMANCE.

RECOMMENDATIONS:

1. INSTALL A LOCAL "SKIN TEMPERATURE" SENSOR BENEATH INSULATION ON PSV-9-509 INLET FLANGE.
 2. ON STEAM TRACED PSV INLET PIPING, INSTALL A STEAM TRAP W/ LIQUID CRYSTAL TEMPERATURE SENSOR.
 3. PRIOR TO STARTUP, IT SHOULD BE STANDARD OPERATING PRACTICE TO CHECK CONDITION OF STEAM TRAP AND VERIFY "SKIN-TEMPERATURE" OF PIPING TO THE INLET OF PSV-9-509. TO PREVENT A FREEZE UP FROM STOPPING PROPER PSV OPERATION.
- OR 4. USE HEAT TRANSFER MEDIA WHOSE FREEZING POINT IS BELOW 0°F.

SL 012076

DOWTHERM HEATER #1
FAULT TREE ID: LOSS OF FLOW - TUBE FAILURE
BY AND DATE: PA KELLEY 9/25/80
BAVIRAL 9/30/80

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Job No. 79.57

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Client PPG - LAKE CHARLES, LA. Ref. _____ Date 9/24/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject DOWTHERM HEATER - LOW FLOW SD Checked By _____

NORMAL DOWTHERM OUTLET TEMP. = 500°F
 MAX. OUTLET TEMP = 550°F
 MAX. TMT TEMP. = 700°F

DESIGN DOWTHERM FLOW THROUGH ONE
 PASS IS 1000 GPM. DESIGN LOW FLOW
 SHUT DOWN IS 400 GPM.

HEAT TRANSFER COEFFICIENT AS % OF DESIGN

$$\% \text{ DECREASE} = \left[\frac{400}{1000} \right]^{0.8} \times 100 = 48\%$$

DESIGN TMT IS 650°F

$$\Delta T \text{ ACROSS } h_2 \text{ IS } \begin{array}{r} 650 \\ - 500 \\ \hline 150^\circ\text{F} \end{array}$$

IN ORDER TO MAINTAIN DESIGN
 HEAT FLUX WITH MAX. TMT OF
 700°F, THE DOWTHERM COEFFICIENT CAN
 BE LOWERED BY $\frac{150}{200} (100)$ OR 75%.

$$\left[\frac{x}{1000} \right]^{0.8} \times 100 = 75\%$$

SL 012077

$$x = 700 \text{ GPM}$$

LOW DOWTHERM FLOW SHUT DOWN = 700 GPM

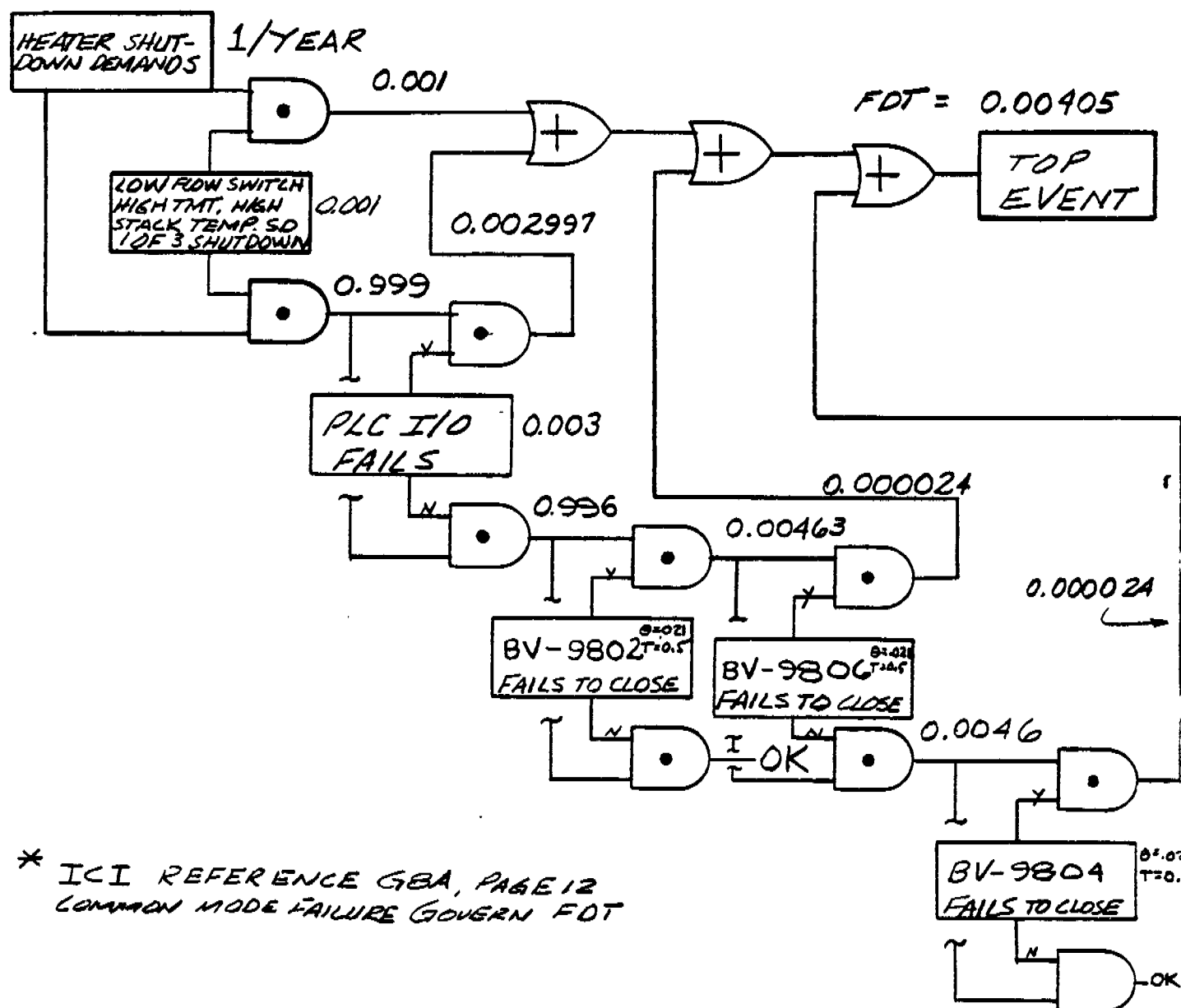
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P. O. Box 3071 Beaumont, Texas 77704 713-842-2417

Page ____ Of ____
Job No. 79.57

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 9/18/80
Job VLM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject DOWTHERM HEATER - SHUTDOWN FDT Checked By _____

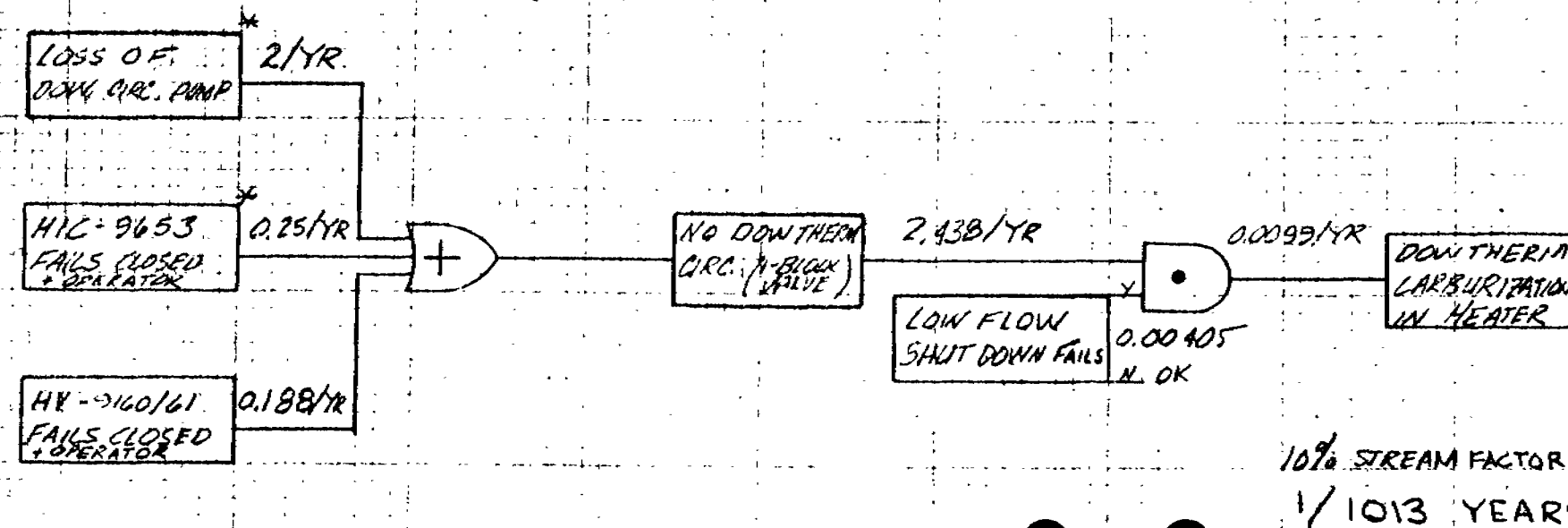
OVERALL FDT OF DOWTHERM HEATER SHUTDOWN SYSTEM



* ICI REFERENCE GEA, PAGE 12
COMMON MODE FAILURE GOVERN FDT

SL 012078

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NOTES

1. TEMPERATURE LOOP TIC-9604 IS NOT A BACKUP SYSTEM FOR LOSS OF FLOW BECAUSE BULK TEMPERATURE OF DOWTHERM IN HEATER WITH NO FLOW IS UNKNOWN! IN A NO FLOW CONDITION, TUBE METAL TEMPERATURE MORE ACCURATELY REPRESENTS BULK TEMPERATURE OF THE HEAT TRANSFER MEDIA IN THE FIRED PORTION OF THE HEATER.
2. OHC-REACTOR INSTRUMENTS PROVIDE ADDITIONAL BACKUP TO LOSS OF DOWTHERM FLOW.

10% STREAM FACTOR
 1/1013 YEARS

NO RECOMMENDATIONS:

* OHC-REACTOR STUDY, FAULT TREE #1

SL 012079

DOWTHERM HEATER #2

FAULT TREE ID: LOSS OF FLOW - DOW CARBURIZATION

BY AND DATE: PA KELLEY 9/26/80

BA VIRNIG 9/30/80

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Job No. 79.57

Client PPG - LAKE CHARLES, LA Ref. _____ Date 10/13/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject DOWTHERM HEATER - VAPOR DETECTOR SD. Checked By _____

USE SERVOMEX, FAILS TO LOW READING - 2 FAULTS/YR

THE DOWTHERM HEATER HAS SIX (6) VAPOR DETECTORS
AROUND THE PERIMETER. ASSUME A VAPOR CLOUD
CONTACTS TWO (2) DETECTORS FROM EVERY DIRECTION.
USE TWO (2) DEGREES OF REDUNDANCY.

$$H = \theta^2 T [1 - \exp(-\theta T / (n+1))]^n$$

$$\theta = 2/\text{YR} \quad \& \quad T = 0.5\text{YR} \quad \text{PER OPERATING YEAR}$$

SINCE AN OPERATING YEAR FOR THE DOWTHERM
HEATER IS ONLY 10% OF A NORMAL YEAR BOTH
THE FAILURE RATE AND TEST PERIOD IS ADJUSTED
TO REFLECT ACTUAL OPERATING TIME.

$$\theta = 0.2/\text{YEAR} \quad ; \quad T = 0.05\text{YEAR}$$

THE TWO ACTUAL TESTS OF THE VAPOR DETECTOR
SHUTDOWN SYSTEM SHOULD BE PRIOR TO THE
SCHEDULED STARTUPS

$$H = 0.2^2 (.05) [1 - \exp(-0.05(.05)/(2+1))]^2$$

$$H = 1.7 (10^{-6})$$

VOID

SL 012080

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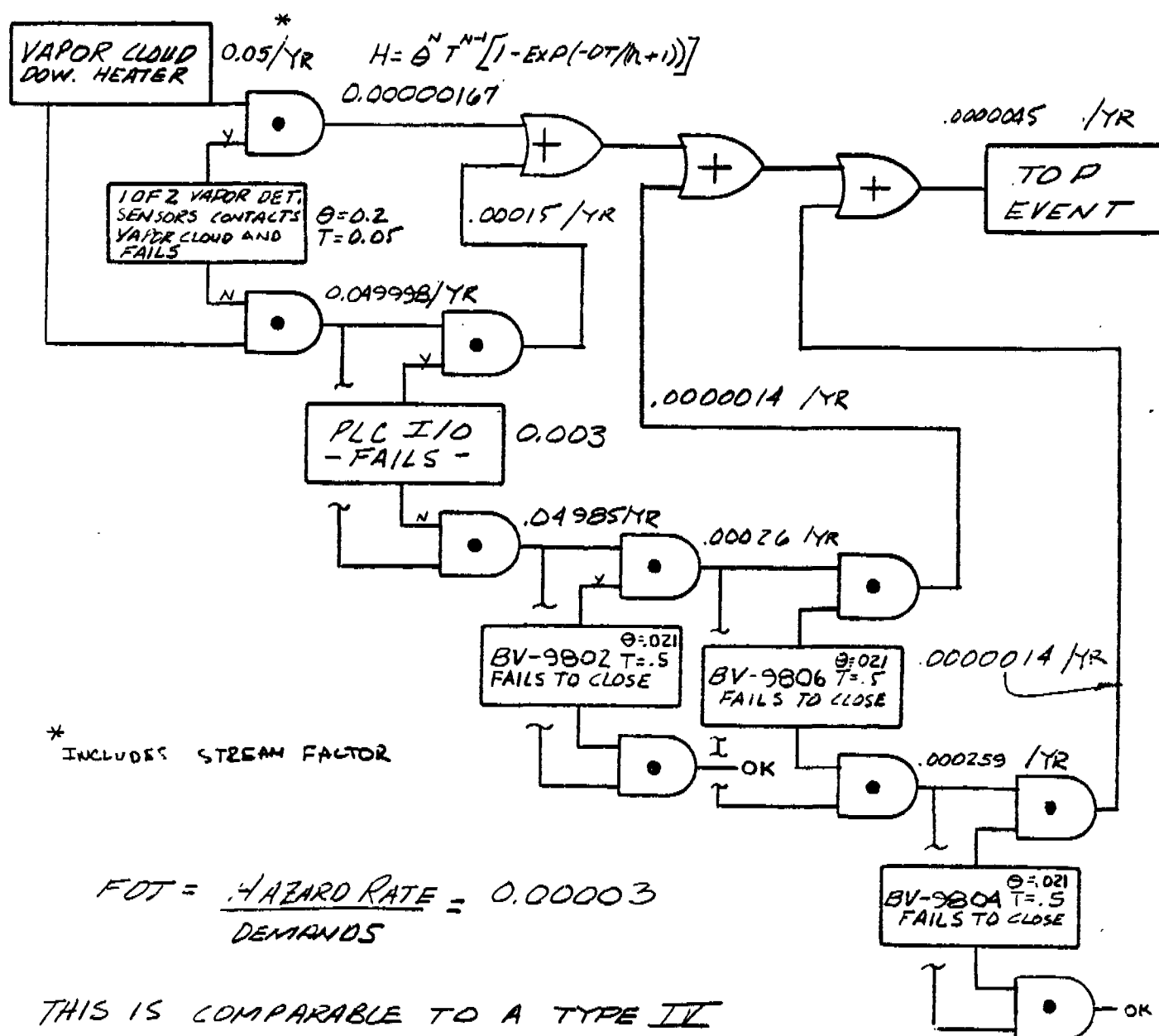
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Page 2 of 2

Job No. 79.57

Client PPG-LAKE CHARLES, LA. Ref. _____ Date 10/13/80
Job VCM II RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject DOWTHERM HEATER - VAPOR DETECTOR SHUTDOWN Checked By _____

OVERALL FDT OF VAPOR DETECTOR SHUTDOWN



$$FDT = \frac{\text{HAZARD RATE}}{\text{DEMANDS}} = 0.00003$$

THIS IS COMPARABLE TO A TYPE II
1 OF 2 REDUNDANT SYSTEM
ICI REF. GBA, PAPER A8 TABLE 3.

VOID

SL 012081

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VAPOR CLOUD
CONTAINS DETECTOR

0.05 / YEAR

VAPOR DETECTOR
SHUTDOWN SYSTEM
- FAILS -

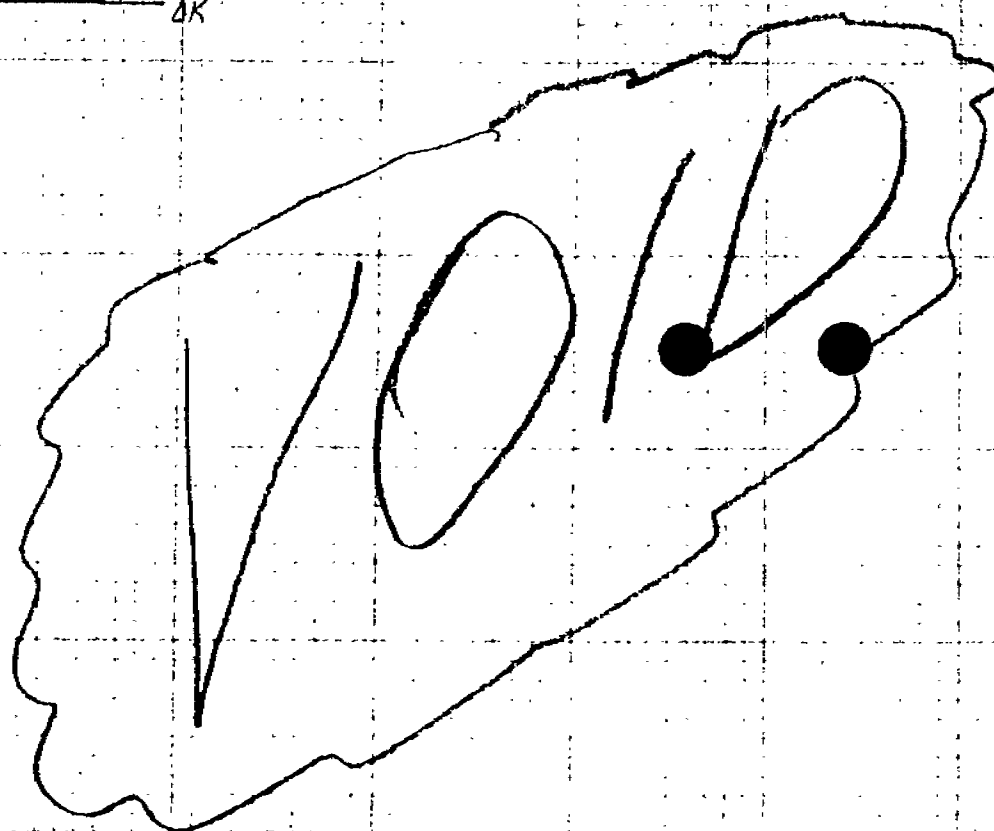
0.00009

N. OK

0.00000045

EXPLOSION

1 / 220,000 YEARS



NO RECOMMENDATIONS

SL 012082

DOVITHERM HEATER #3

FAULT TREE ID: VAPOR DETECTOR SHUTDOWN

BY AND DATE: PA KELLEY 9/27/80

BAUERMEIER 9/30/80

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ENGINEERS & DESIGNERS

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Page 1 Of 1

Job No. 7957

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 10/1/80

Job VII - RELIABILITY STUDY, LEVEL III By PA KELLEY

Subject DOWTHERM HEATER - FAILURE RATES Checked By BAVIRNIG

ILI REPORT MD 19128/1 COPY No. 60 (#5)

SHUTOFF VALVE IN GAS SERVICE - SLAM SHUT

$\theta = 0.021 \text{ f/y}$; REMAINING OPEN

SEE pg 1 of 2 OF FAULT TREE # 3 SUPPORT
INFORMATION FOR FAILURE RATE AND TESTING
OF VAPOR DETECTORS.

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11-1145

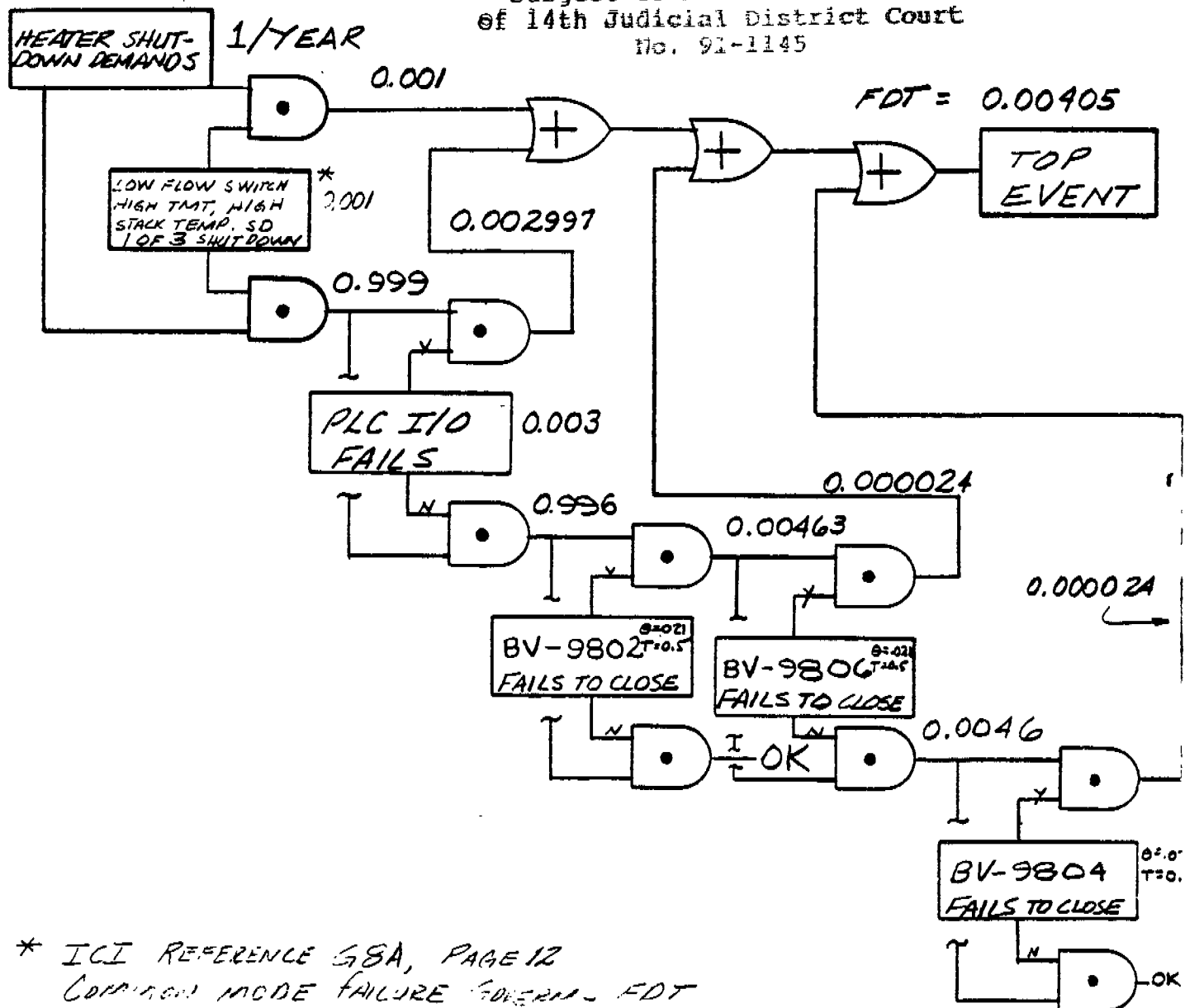
SL 012083

Client PPS - LAKE CHARLES, LA. Ref. _____ Date 9/18/80
 Job VLM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject DOWTHERM HEATER - SHUTDOWN FDT Checked By BA VERNIG

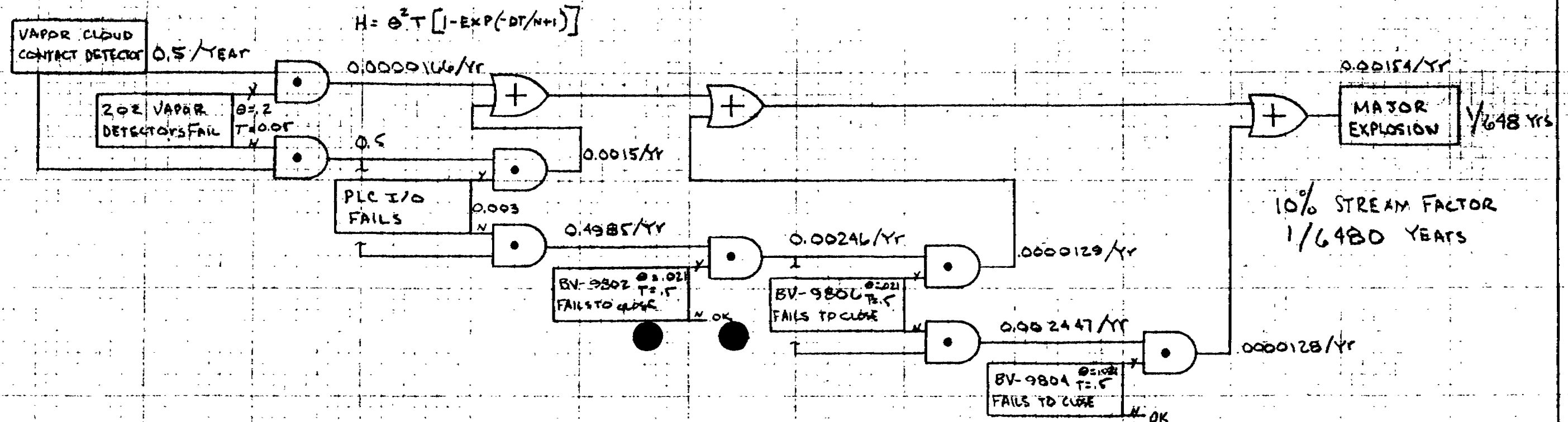
OVERALL FDT OF DOWTHERM HEATER SHUTDOWN SYSTEM

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 No. 91-1145



* ICI REFERENCE 58A, PAGE 12
 COMMON MODE FAILURE GOVERN - FDT



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RECOMMENDATIONS:

1. TEST VAPOR DETECTORS PRIOR TO EACH HEATER STARTUP. TEST SHOULD INCLUDE OPERATION OF THE 3 GAS VALVES. (MINIMUM OF 12 TESTS/YEAR)

SL 012085

DOWTHERM HEATER #4
FAULT TREE ID: GAS IN FURNACE AFTER VAP. DET. SHUTDOWN
BY AND DATE: P.A. KELLEY 9/29/80
BAVIRNICK 9/30/80

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 9/29/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject DOWTHERM HEATER - TIC LOOP FAILURES Checked By BAVIRNII

HEATER OUTLET TEMPERATURE CONTROL, TIC-9604

<u>COMPONENT</u>	<u>FAILURES</u>	<u>DANGER - FAST & OPEN</u>
TE	0.2 x 1/9	
TT	0.5 x 1/9	
TIC	0.5 x 1/9	
TV (FAILS CLOSED)	0.2 x 1/9	
POSITIONER	0.2 x 1/9	

$$\theta = 0.18 / \text{YR}$$

FAILURE OF TEMPERATURE LOOP IN THE OPEN POSITION PLACES DEMANDS ON :

1. HIGH TUBE WALL TEMPERATURE
2. HIGH STACK TEMPERATURE
3. HIGH DOWTHERM OUTLET TEMPERATURE

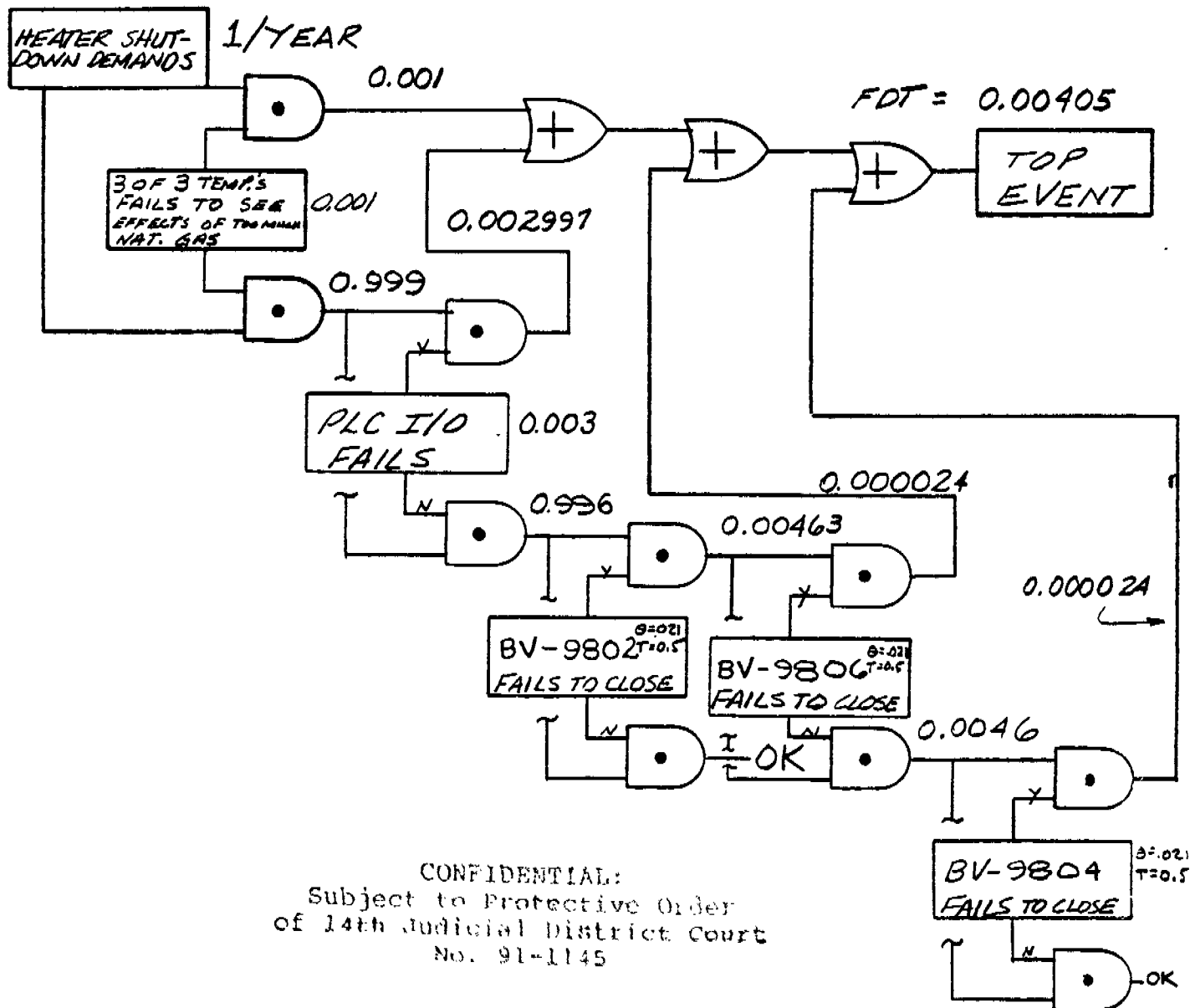
USE COMMON MODE FAILURE OF THE THREE SEPARATE TEMPERATURE SENSORS (PROBABLY USING A COMMON INSTRUMENT TUBE RACK, JUNCTION BOXES AND POTENTIOMETER USED TO INDICATE TEMPERATURE) OF 0.001.

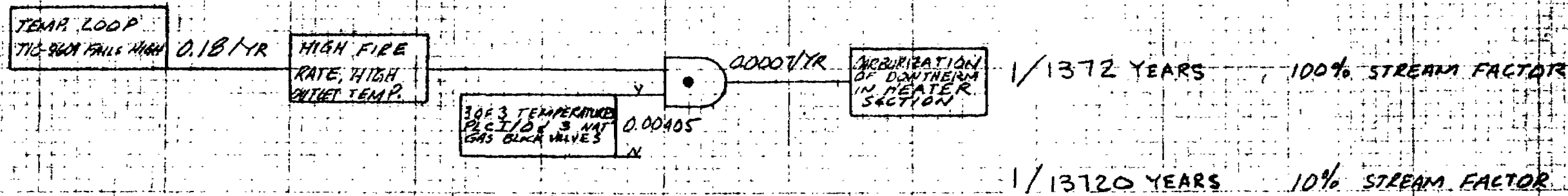
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 No. 91-1145

Client PP-1 - LAKE CHARLES, LA Ref. _____ Date 9/14/80
 Job WHA II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject DOWTHERM HEATER - TIC LOOP FAILURES Checked By BAVIRNIG

OVERALL FDT OF DOWTHERM HEATER SHUTDOWN SYSTEM





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No. 91-1145

NO RECOMMENDATIONS

SL 012088

DOWTHERM HEATER #5
FAULT TREE ID: TEMP LOOP FAIL OPEN - DOW CARBURIZATION
BY AND DATE: PA KELLEY 9/29/80
SA VERNIL 9/30/80

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APPENDIX II

SL 012089

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No. 91-1145

- 3 - 4 Dow PMP Stop - This is a pushbutton/lamp, unlit normal and
HS/HI-9953-A/B steady red when both pumps are down. Momentary
 pushing of this pushbutton will trip either or
 both of No. 2 OHC Rx dowtherm circulation pumps.
 The pumps can only be started in the field.

The switches and lights located on OIP-6B associated with the dowtherm system are:

- DV-8/D Furn. Run/
Bypass - This is a key operated switch used to bypass the
6BB-8 dowtherm heater shutdown and deluge valve No. 8
 that is activated by vapor detectors 6B-8, 9 &
 10. It does not bypass the remote manual trips
 or any other shutdown feature. While in the by-
 pass position, a red indicator light labeled
 "System Bypass" will flash. This light is located
 at the top of this panel.
- DV-12/SD Run/Bypass - This is a key operated switch used to bypass the
 dowtherm heater shutdown and deluge valve No. 12
 that is activated by vapor detectors 6B-13, 14
 & 15. It does not bypass the remote manual trips
 or any other shutdown feature. While in the bypass
 position, the red indicator light labeled "System
 Bypass" will flash.
- DV-8/D Furn. Trip - This is a pushbutton switch. When momentarily
HS 6BD-8 depressed, this switch will trip the dowtherm
 heater and cause the deluge valve No. 8 to open.
- DV-12/SD Trip - This is a pushbutton switch. When momentarily
6 BD-12 pressed, this switch will trip the dowtherm heater
 and cause the deluge valve No. 12 to open.

Shutdown Dow Furn. Trip - This is a red indicator lamp that flashes when any of the above vapor detector shutdown features initiates an intended dowtherm furnace shutdown to the "Flame Management System". The lamp is steady red when acknowledged and unlit in run.

VII. Dowtherm Heater Start-up Sequence

1. The Dowtherm Furnace run-block switch on OIP-2 must be in the run position.
2. Place "Stop-Run" switch in the "Stop Alarm Reset" position, apply power to panel. "Power On" light should be on.
3. Close the 1 1/2" and 3/4" natural gas valves immediately upstream of the burners and pilots. Be sure that the factory mutual valve and the fuel supply solenoid valves are closed and the fuel vent solenoid valve is open.
4. Establish 1000 GPM dowtherm flow through each pass.
5. Open the secondary air registers wide open.
6. Place "Stop-Run" switch in run position. The "Limits Normal" light and "Purging" lights should come on: If the "Limits Normal" light does not come on, check the status lights on the first out annunciator to determine which limit is not satisfied. The limits which are not satisfied must be cleared. If the "Purging" light does not come on, check that the proof of closure switches on the factory mutual valve and the fuel supply solenoid valves are made.

7. At the end of the purge period, 5 minutes, the purge light will go out and the "Purge Complete" light will come on. Power is now available to the upstream fuel supply solenoid valve. The fuel vent valve should go closed at this time. Manually open the upstream fuel supply solenoid valve. The fuel supply pressure control valve should be set to maintain 30 PSIG downstream.
8. Check the atmosphere inside the furnace with an explosimeter to assure that no residual gases are left in the heater.
9. Open hand block valves on the pilot header. Pilot gas pressure should be set from 2 to 5 PSIG.
10. Push the "Push To Ignite Pilots" switch. The "Ignition On" light will come on and the run trip lamp on OIP-2 will go out. If the ignition on light does not come on, verify that proof of open switch on the upstream solenoid valve is made. Hold the "Push To Ignite Pilots" switch until the "All Pilots On" light is on. If all pilots do not ignite, and the U/V scanners do not see a pilot flame within 10 seconds, the "Ignition Time Limit" light will come on.
11. To clear this alarm, push the "Ignition Time Limit Reset" button and hold until the "Ignition Time Limit Resetting" light comes on. After approximately 40 seconds the "Ignition Time Limit" and "Ignition Time Limit Resetting" lights will go out and a restart may be initiated with step 8.

NOTE: During steps 4 through 10 the downstream solenoid and factory mutual valves must remain closed and be proven so. If at anytime during steps 4 through 10 either of these valves are opened, the system will trip and you must place the "Stop-Run" switch in "Stop Alarm Reset" position and return to step 4 to start again.

12. Place the temperature control valve in manual and open it 25% open. Close the secondary air register to $\frac{1}{2}$ open. Check to see that the primary air door is partially open.
13. After the pilots are on and so established by the U/V scanners, then power should become available to the downstream solenoid valve. Manually open the downstream solenoid valve. (Note: The factory mutual valve must remain closed and be proven so or the downstream solenoid valve will not open.)
14. Open hand block valves on the main burner headers.
15. The main burners are ignited by slowly opening the factory mutual valve. (It should be located so that the ignition of the main burners can be visually monitored.) If the flames become too large in the process of opening the factory mutual valve, then close back on the temperature control valve until the factory mutual valve is fully open and the temperature control valve is giving satisfactory flame size. Adjust the primary air door to give the minimum size stable flame. Adjust the secondary air register to give the desired excess air.
16. The main burners only can be turned off by pushing the "Main Burners Stop" switch. If this method of stopping main burners is used, the factory mutual valve must be closed and return to step 12 to relight the main burners.
17. The main burners and pilots can be shutdown by placing the "Stop-Run" switch in the "Stop Alarm Reset" position, by the remote manual trip switch on OIP-2 and OIP-6B. To relight return to step 3.

18. If any limit opens anytime after the "Limits Normal" light comes on, the malfunction will be annunciated by the first out annunciator and all burners (main and pilot) will be shutdown. The fires out lamp on OIP-2 will flash. The unit may be restarted by clearing the malfunction and returning to step 1.
19. If a flame failure occurs at anytime the "Flame Failure" light will come on and all burners (main and pilot) will shutdown. The fires out lamp on OIP-2 will flash. A restart can be initiated by returning to step 1.

VIII. Typewritten alarm messages associated with the Dowtherm Furnace Shutdown System are provided by PLC I. the amber PLC I typewriter message indicator alarms when the PLC I operates. These alarms are provided prior to shutdown and when shutdown occurs. They are also provided during start-up and anytime the shutdown system is bypassed.

The typewritten messages for the dowtherm furnace provided by PLC I will state the time, seconds and tenths of a second, dowhterm furnace then a code number. The code number will indicate the following:

- 210 Dowtherm Furnace Deluge Valve Initiated Trip
- 217 Dowtherm Furnace Trip Flame Out
- 221 OHC Rx Area Dowtherm Furnace High Vapor Detector Bypassed

FURNACE SHUTDOWN SYSTEM

- I. The furnace shutdown system is provided to stop fuel gas firing of one or both furnaces in the event that undesirable conditions develop on the furnace or in the area. In addition to stopping the firing of the furnace, in the case of a vapor detector shutdown, snuffing steam is automatically started into the firebox and the deluge below the furnaces is started. The system also monitors the operation and start-up of fuel gas burners. The undesirable conditions to be protected against are:
 1. Loss of flow to one or more passes on a furnace, while it is being fired, resulting in tube rupture or damage, or refractory or structure damage.
 2. Ignition of a vapor cloud by the furnaces, resulting in a fire or explosion.
 3. Accumulation of fuel gas in the furnaces, either during start-up ignition or during normal operation, which could result in an explosion due to fuel gas vapor cloud within the furnace.
- II. The conditions that will cause a shutdown are:
 1. High or low fuel gas pressure measured at downstream side of the flow control valve to each furnace.
 2. Any damper, plenum or stack, going fully closed.
 3. Total Flame Failure.
 4. Manual pushbutton in the field.
 5. Power failure to the Flame Management System or PLC III.
 6. Loss of flow as determined by any two out of three inputs of the two furnace feed flows and one tube metal temperature per pass.
 7. Any two vapor detectors designated to the furnace shutdown system sensing a LFL of 40%.

8. Manual pushbutton in the control room on the vapor detector panel,
OIP-6A.

9. Manual pushbutton in the control room on the furnace operators
panel, OIP-4.

III. The actual inputs are:

#1 Furnace (To PLC III)

FT-3011 #1 Furnace #1 Pass Feed Flow

FT-3016 #1 Furnace #1 Pass Feed Flow

FT-3012 #1 Furnace #2 Pass Feed Flow

FT-3017 #1 Furnace #2 Pass Feed Flow

TE-3616 #1 Furnace #1 Pass Radiant Section at Floor TMT

TE-3618 #1 Furnace #2 Pass Radiant Section at Floor TMT

TE-3621-B #1 Furnace Center Chamber Bridgwall Temperature

HS-3809 Board Mounted Trip Switch

#2 Furnace (To PLC III)

FT-3061 #2 Furnace #1 Pass Feed Flow

FT-3066 #2 Furnace #1 Pass Feed Flow

FT-3062 #2 Furnace #2 Pass Feed Flow

FT-3067 #2 Furnace #2 Pass Feed Flow

TE-3666 #2 Furnace #1 Pass Radiant Section at Floor TMT

TE-3668 #2 Furnace #2 Pass Radiant Section at Floor TMT

TE-3671-B #2 Furnace Center Chamber Bridewall Temperature

HS-3859 Board Mounted Trip Switch

Vapor Detector System (To PLC III)

6A-1, 6A-2, 6A-3, 6A-4, 6A-5, 6A-6, 6A-7, 6A-8, 6A-9, 6A-10, 6A-11, 6A-12

HS-3800 Board Mounted Trip Initiated Switch (Manual)

HS-3905 Field Mounted Trip Initiated

HS-3801 Field Mounted Reset Switch

#1 Furnace Flame Management System (FMS) (KTI Package)

ZSL-3803 #1 Furnace Natural Gas Double Block & Bleed Position Switch

ZSL-3805 #1 Furnace Stack Damper Position Switch
ZSH-3805

ZSL-3806 #1 Furnace South Chamber Plenum Damper Position Switch
ZSH-3806

ZSL-3807 #1 Furnace Center Chamber (South) Plenum Damper Position Switch
ZSH-3807

ZSL-3808 #1 Furnace Center Chamber (Pair) Plenum Damper Position Switch
ZSH-3808

ZSL-3817 #1 Furnace Center Chamber (Pair) Plenum Damper Position Switch
ZSH-3817

ZSL-3818 #1 Furnace Center Chamber (North) Plenum Damper Position Switch
ZSH-3818

ZSL-3819 #1 Furnace North Chamber Plenum Damper Position Switch
ZSH-3819

ZSL-3832 #1 Furnace Natural Gas to Pilots Block Valve Position Switch

ZSL-3834 #1 Furnace Natural Gas Manual Vent Valve

ZSL-A051 to #1 Furnace, #1 to #28 Burner Supervisory Valve Position Switch
ZSL-A078

PCL-3621 #1 Furnace Center Chamber Bridgwall Temperature High Switch

PLC-3809 #1 Furnace Trip Switch from Control Room

PSH-3423 #1 Furnace Natural Gas Pressure High Switch

PSL-3423 #1 Furnace Natural Gas Pressure Low Switch

BSL-A001 to #1 Furnace, #1 to #28 Burner Flame Out Switch
BSL-A028

PSL-18 #1 Furnace Operators Panel Low Pressure Switch

PSL-19 #1 Furnace Fireeye Amplifier Cabinet Low Pressure Switch

PSL-20 #1 Furnace Controller Cabinet #1 Low Pressure Switch

PSL-21 #1 Furnace Controller Cabinet #2 Low Pressure Switch

HS-A101 to #1 Furnace, Burner #1 to #28 Ignition Switch
HS-A128

HS-A506 #1 Furnace Trip Switch Field

HS-A001 #1 Furnace Alarm Reset Switch

HS-A500 #1 Furnace Start Switch

#2 Furnace Flame Management System (FMS) (KTI Package)

ZSL-3853 #2 Furnace Natural Gas Double Block & Bleed Position Switch

ZSL-3855 #2 Furnace Stack Damper Position Switch
ZSH-3855

ZSL-3856 #2 Furnace South Chamber Plenum Damper Position Switch
ZSH-3856

ZSL-3857 #2 Furnace Center Chamber (South) Plenum Damper Position Switch
ZSH-3857

ZSL-3858 #2 Furnace Center Chamber (Pair) Plenum Damper Position Switch
ZSH-3858

ZSL-3867 #2 Furnace Center Chamber (Pair) Plenum Damper Position Switch
ZSH-3867

ZSL-3868 #2 Furnace North Chamber (North) Plenum Damper Position Switch
ZSH-3868

ZSL-3869 #2 Furnace North Chamber Plenum Damper Position Switch
ZSH-3869

ZSL-3887 #2 Furnace Natural Gas to Pilots Block Valve Position Switch

ZSL-3889 #2 Furnace Natural Gas Manual Vent Valve Position Switch

ZSL-B051 to #2 Furnace, #1 to #28 Burner Supervisory Valve Position Switch
ZSL-B078

PLC-3671 #2 Furnace Center Chamber Bridgwall Temperature High Switch

PLC-3859 #2 Furnace Trip Switch from Control Room

PSH-3473 #2 Furnace Natural Gas Pressure High Switch

PSL-3473 #2 Furnace Natural Gas Pressure Low Switch

BSL-B001 to #2 Furnace #1 to #28 Burner Flame Out Switch
BSL-B020

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PSL- #2 Furnace

PSL- #2 Furnace

PSL- #2 Furnace

PSL- #2 Furnace

HS-B101 to #2 Furnace, Burner #1 to #28 Ignition Switch
HS-B128

HS-B506 #2 Furnace Trip Switch (Field)

HS-B001 #2 Furnace Alarm Reset Switch

HS-B500 #2 Furnace Start Switch

- IV. . FT-3011, FT-3016 measure #1 Furnace #1 pass feed flow. If FT-3011 drops below 15 gpm then a vote is cast after 30 seconds to trip the #1 furnace due to loss of feed. FT-3016 functions in the same manner. An alarm is generated at 25 gpm on dropping flow.
- . TE-3616 measures #1 Furnace #1 pass outlet TMT. If this temperature rises above 1550⁰F then a vote is cast to trip the furnace due to loss of feed. An alarm is generated at 1500⁰F on rising temperature.

If any two votes are cast by FT-3011, FT-3016 or TE-3616, then the #1 Furnace is shutdown.

- . FT-3012, FT-3017 measure #1 Furnace #2 pass feed flow. TE-3618 measures #1 Furnace #2 pass outlet TMT. These each cast one vote to shutdown the furnace at the same values as given above for FT-3011, FT-3016 and TE-3616 respectively.

If any two votes are cast by FT-3012, FT-3017 or TE-3618, then the #1 Furnace is shutdown.

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- . TE-3621-B measures the #1 Furnace center chamber bridgwall temperature. This is used to switch on a signal to the #1 Furnace Flame Management System at 1400⁰F. This signal is used to bypass purging on furnace start-up sequence if the temperature is above 1400⁰F.
- . HS-3809 is a board mounted trip switch that can cause the shutdown of #1 Furnace.

All of the above mentioned shutdowns are the stopping of furnace firing only.

- . FT-3061, FT-3066 measure the #2 Furnace #1 pass feed flow. TE-3666 measures the #2 Furnace #1 pass outlet TMT. These function in the same manner as FT-3011, FT-3016 and TE-3616 described above except they function to shutdown #2 Furnace.
- . FT-3062, FT-3067 measure the #2 Furnace #2 pass feed flow. TE-3668 measures the #2 Furnace #2 pass outlet TMT. These function the same as FT-3012, FT-3017 and TE-3618 described above except they function to shutdown #2 Furnace.
- . TE-3671-B measures the #2 Furnace center chamber bridgwall temperature. This is used the same as TE-3621-B except on the #2 Furnace Flame Management System.
- . HS-3859 is a board mounted trip switch that can cause the shutdown of #2 Furnace.

All of the above mentioned shutdowns are the stopping of furnace firing only.

- . Vapor detectors 6A-1, 6A-2, 6A-3, 6A-4, 6A-5, 6A-6, 6A-7, 6A-8, 6A-9, 6A-10, 6A-11 and 6A-12 are used to detect the presence of flammable vapors in the furnace area and the adjacent south end of the process area. These detectors are also used as inputs to the deluge system. Refer to the deluge system write-up for information concerning operation of that system.

Should anyone of these detectors sense a 20% LFL of flammable vapors then a vapor detector alarm will sound. At 40% LFL, anyone of these detectors will cause the deluge valves in the furnace area and south end of the process area to be turned on. (Including the hydroshield.)

At 40% LFL, each of these detectors cast one vote to shutdown both of the furnaces. If any two of these detectors cast a vote then both furnaces are shutdown. In addition to stopping firing of the furnaces, snuffing steam is automatically started to both furnaces and deluge valve #1 (water spray below furnaces) is started. Each detector may cast only one vote per occurrence. Pressing the reset button on the particular alarming detector or causing that detector to alarm twice while the system is "Armed" will not result in a shutdown. It requires that another detector reach 40% LFL for a shutdown to be initiated. The occurrence is "over" at the point when the reset switch, HS-3801 is pressed.

- . HS-3800 is a board mounted trip initiated switch that manually activates the shutdown of both furnaces in exactly the same manner as the vapor detector shutdown. It stops firing of both furnaces, turns on snuffing steam to both furnaces and turns on deluge valve #1. In addition, it also starts deluge valves #2 and #3 since these would also be operating in the event of an automatic vapor detector initiated shutdown of the furnaces.

- HS-3905 is a field mounted trip initiated switch that functions in exactly the same manner as HS-3800.
- HS-3801 field mounted reset switch is used in the event that one of the vapor detectors cast a vote to shutdown the furnaces. If the area is determined to be safe and the reset button on the alarming detector is pressed, then the field mounted reset switch, HS-3801, is pressed and the vote cast by the detector is cancelled. This switch is located on the furnace oxygen analyzer house.

If the detector is determined to be faulty then it should not be reset. This will leave it in the alarm state. The reset in the field, HS-3801, may then be pressed and the vote cast by the detector will be cancelled. This bypasses that detector as far as the furnace shutdown system and deluge valves #2 and #3 are concerned. If at anytime the detector is determined to be OK, it may be unbypassed by pressing the reset on the front of the detector.

This switch is also used after a shutdown has occurred, to reset the system.

All of the above described inputs are to PLC III. All of the functions and logic are provided by PLC III.

The following inputs are related to the Flame Management System (FMS) for #1 Furnace. The following is a description of how these inputs function in that system. In all cases the shutdown that results from the FMS is to stop gas firing of the furnace.

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- . ZSL-3803, #1 Furnace Natural gas double block & bleed switch is used by the FMS to identify when the main gas supply to #1 Furnace is off. This valve must be closed prior to purging the furnace for start-up.
- . ZSH-3805, #1 Furnace Stack damper wide open position switch is used by the FMS to identify if the stack damper is wide open.
- . ZSH-3806, 3807, 3808, 3817, 3818 and 3819 - #1 Furnace plenum dampers wide open position switches are used by the FMS to identify if the plenum dampers are wide open.

All of the dampers, both in the stack and in the plenum must be wide open prior to purging the furnace for start-up.

- . ZSL-3805, #1 Furnace Stack damper closed position switch is used by the FMS to identify if the stack damper goes closed.
- . ZSL-3806, 3807, 3808, 3817, 3818 and 3819 - #1 Furnace plenum dampers closed position, switches are used by the FMS to identify if any plenum dampers go closed.

If any dampers go closed, then the FMS sounds an audible alarm in the field. After 10 seconds the FMS will shutdown the #1 Furnace. If the damper is reopened within 10 seconds the shutdown is reset. Damper switches 3808 and 3817 must both go closed, since both of these dampers supply air to the center chamber, center row of burners. The air supply is not shut-off until both dampers are closed.

- . ZSL-3832, #1 Furnace Natural gas to Pilots Block valve position switch is used by the FMS to identify if the pilot valve is closed. This valve must be closed in order to purge the furnace for start-up. If

this valve is closed during operation of the furnace, it will cause the furnace to trip. Upon opening this valve after the purge is completed, (1) power is supplied to the pilot gas header vent valve causing it to close after a 5 second delay (to allow air to purge from the line), (2) the light labeled "OK to Light" on the operators panel comes on, (3) power is turned on to all of the fireye amplifiers, (4) a permissive circuit is supplied to light pilots and continue with the furnace start-up.

- . ZSL-3834, #1 Furnace Natural Gas Manual vent valve position switch is used by the FMS to identify the position of the manual vent valve. This switch operates a light on the operators panel for the FMS (in the field). This light serves as a reminder that this valve must be cleared prior to putting natural gas to the furnace.
- . ZSL-A051 to ZSL-A078, #1 Furnace, #1 to #28 Burner, supervisory valve position switches are used by the FMS to identify the position of the supervisory valves. These valves must all be closed prior to purging #1 furnace for start-up. After purging, none of these valves can be opened until its corresponding pilot is on. If any valve is open before the main fuel gas block valve is opened, it will result in the furnace having to be purged again. After this valve is opened, if any supervisory valve is opened before its corresponding pilot is hit, the local audible alarm for #1 Furnace will sound. It can only be silenced by closing the supervisory valve. The supervisory valve must be closed before a permissive circuit can be obtained for lighting a pilot. If at anytime after a main burner is lit, it goes out, then the supervisory valve must be closed before the local audible alarm will silence. To

allow for malfunctioning position switches, the audible will silence 10 minutes after the reset is pressed even if the valve is left open.

- . PLC-3621, #1 Furnace, Center Chamber Bridewall Temperature High Switch, is used by the FMS to determine if the furnace firebox temperature is above 1400⁰F. If the temperature is above 1400⁰F after a shutdown, then the purge cycle may be skipped. This signal is provided to the FMS by PLC III. (See TE-3621-B above.)
- . PLC-3809, #1 Furnace, Trip Switch is used by the FMS to determine if a furnace shutdown is called for by PLC III. This shutdown can be the result of any of the functions or inputs to PLC III described above.
- . PSH-3423, #1 Furnace, Natural Gas Pressure High Switch, is used by the FMS to determine gas pressure in the main fuel gas header downstream of the fuel gas flow control valve. If at anytime after the first main burner is lit, the gas pressure goes above 15 PSIG, a furnace shutdown will occur. The FMS also uses this signal to send an input to the control room alarm system via UJR-3424.
- . PSL-3423, #1 Furnace, Natural Gas Pressure Low Switch, is used by the FMS to determine gas pressure in the main gas header downstream of the fuel gas flow control valve. If at anytime after the first main burner is lit, the gas pressure goes below 0.5 PSIG, a furnace shutdown will occur. The FMS also uses this signal to send an input to the control room alarm system via UJR-3423.
- . BSL-A001 to BSL-A028, #1 Furnace, #1 to #28 burner on switches are used by the FMS to identify which pilots and/or burners are lit. If at any time during furnace operation all fires are detected to be out, then a

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furnace shutdown will occur. At anytime if one or more fires (pilot or burner) go out due to failure then the FMS sends an alarm to the control room via PLC-3812. This alarm identifies to the operator to go to the FMS operators panel to see what fires have gone out and take appropriate action. The signal to the control room can be reset at this point even if the fires are not relighted. In the event that all fires are detected to be out and the main gas valve is indicated to be closed (ZSL-3803) and the pilot gas supply valve is indicated to be closed (ZSL-3823), the FMS will send a signal to the control room, via PLC-3813, indicating all fires out. This indicator lamp on OIP-4 should come on after any trip is initiated, to confirm that the shutdown has occurred properly.

- . PSL-18 #1 Furnace, Operators Panel, Low Pressure Switch is used by the FMS to determine if the cabinet purge pressure drops below 0.1 PSIG. In the event that it does, the FMS will sound the audible alarm. The alarm can be silenced by pressing the reset. The FMS also turns on a low purge pressure alarm light on the operators panel, that will stay on as long as the low pressure is experienced.
- . PSL-19 #1 Furnace, Fireye Amplifier Cabinet, Low Pressure Switch is used by the FMS in exactly the same manner as PSL-18. In addition to a light on the operators panel, a light is also turned on on the Fireye Cabinet.
- . PSL-20 #1 Furnace, Controller Cabinet #1, Low Pressure Switch functions exactly the same as PSL-19.
- . PSL-21 #1 Furnace, Controller Cabinet #2, Low Pressure Switch functions exactly the same as PSL-19.

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- . HS-101 to HS-128, #1 Furnace, Burner #1 to #28, Ignitor Switch is used by the FMS to initiate a pilot ignition sequence. After the OK to Light indicator is on, pressing any ignitor switch initiates a 15 second attempt to light the associated pilot. (The pilot gas solenoid is turned on during the attempt.) If the pilot is ignited during the period, as indicated by the associated Fireeye switch, BSL-A001 to BSL-A028, then the pilot will remain on. If at the end of the sequence the flame is not on, the pilot gas and ignitor are turned off and a 50 second waiting period is imposed. If during the 15 second trial the pilot fire comes on, the ignitor is stopped. If the fire goes out during the 15 second period, the ignitor will automatically come back on for the remainder of the 15 seconds. If the pilot is lighted and later goes off due to failure, no 50 second waiting period is imposed.
- . HS-506, #1 Furnace, Trip Switch is mounted on the FMS operators panel and is used by the FMS to initiate a trip of #1 Furnace.
- . HS-001, #1 Furnace, Alarm Reset switch is mounted on the FMS operators panel. It is used to silence the audible alarm for #1 Furnace and to reset the flame failure alarm, PLC-3812, that is sent to the control room.
- . HS-500, #1 Furnace, Start Switch is mounted on the FMS operators panel. It is used to initiate the purge cycle on furnace start-up.

The inputs for the #2 Furnace Flame Management System are listed on page 4 and 5. The function of these inputs are exactly the same as that described for the corresponding inputs to the #1 Furnace Flame Management System.

- V. There are two levels of shutdown associated with the furnace shutdown system. The first level, is a shutdown of the fuel gas firing of either furnace. In this case shutdown means that: (1) All of the maxon valves on each of the 28 burners are closed. This is done by turning off the 120 volt AC power supplied to each by the FMS, (2) All of the pilot solenoid valves on each of the 28 burners are closed. This is done by turning off the 120 volt AC power supplied to each by the FMS, (3) Turning off all power to each of the 28 Fireye amplifier circuits supplied to them by the FMS, (4) Closing the pilot gas supply valve and opening the pilot gas bleed valve. This is done by turning off the 120 volt power supplied by the FMS to both of these valves. This double blocks and bleeds the pilot gas supply, (5) Closing the main fuel gas by turning off the 120 volt power, supplied by the FMS, to the main gas double block and bleed. This causes the two block valves in the main fuel gas to close and the bleed valve to open. It also closes the gas flow control valve by de-energizing a solenoid valve in the air supply to the diaphragm; and (6) the FMS is put into a logic state that requires that it be taken through a start-up sequence in order to restart the furnace.

The first level of shutdown is managed, as described above, by the Flame Management System. This level of shutdown is caused when any of the input items, which are connected to the Flame Management System, indicate that a shutdown is necessary. In addition, this level of shutdown may be involved from the control room by PLC III. This is accomplished by PLC III sending a signal to the Flame Management System indicating for it to cause a furnace shutdown. This can result from any of the input items to PLC III, related to the loss of feed flow, indicating that a shutdown is necessary. These are described above in Part IV.

The second level of shutdown is an extension of the first level. It is invoked by PLC III as a result of vapor detector inputs indicating that a shutdown is required. In this case, both furnaces are shutdown, exactly the same as described above, by a signal being sent from PLC III to the Flame Management System for each furnace, #1 and #2. In addition to this, several other things are done which are managed directly by PLC III. These are: (1) Snuffing steam is started to both furnaces. This is done, by PLC III turning off 120 volt power to solenoids HY-3810 and HY-3811 (#1 Furnace) and HY-3860 and HY-3861 (#2 Furnace) which are in the air and nitrogen supply to the diaphragms of HV-3810, HV-3811, HV-3860 and HV-3861 respectively. (2) Deluge valve #1 is started. This is done by turning off 120 volt power to DV-1 which starts water flow by bleeding air pressure off of the deluge valve activation circuit. (3) Note that deluge valves #2 and #3 will already be on as a result of the first detector reading the 40% LFL. Refer to the deluge system write-up for details on the operation or activation of deluge valves or the system in general.

The second level of shutdown may also be activated as described above in Part IV by a board mounted hand switch, HS-3800, or a field mounted hand switch, HS-3905.

The vapor detector initiated shutdown of both furnaces requires that two detectors reach a 40% LFL.

When the first detector reaches the 40% LFL, the shutdown system is termed to be in an "Armed" state. Deluge valves #2 and #3 will be activated by the detector, when it reaches 40% LFL. If the problem causing the detector to alarm can be corrected before a second alarm reaches 40% LFL, then the

shutdown system may be disarmed. This is done by pressing a reset switch, HS-3801, located in the furnace area. The "Armed" light will be extinguished when HS-3801 is pressed. The deluge valves will continue until the water flow is manually stopped and the deluge valves reset in the field. In order to correct the problem causing the detector to alarm, the following considerations apply: (1) If a small leak is the cause of the alarm, and it is safe to approach the leak and terminate it, this should be done. Then the detector may be reset, on the detector front panel and then the field reset, HS-3801, may be pressed to disarm the system. (2) If the alarm appears to be the result of a faulty detector, the detector should not reset. The furnace area should be carefully inspected to be sure there are no small leaks. This is preferably done with a portable gas detector. If the area is safe, then the field reset, HS-3801, may be pressed and the system will be disarmed. The faulty detector should be left unreset. This will bypass the faulty detector, as described above, until it can be repaired. (3) If there is any doubt as to whether the area is safe to enter, then the system should be left armed. If a second detector reaches 40% LFL, then the system has performed as intended.

If a shutdown is caused by a second detector, then the system responds, as described above for a level two shutdown. After the problems that caused the shutdown, such as a vapor cloud, have been corrected the shutdown should be reset. This is done using HS-3801. When this button is pressed it will (1) cause snuffing steam to stop immediately, (2) extinguish the trip initiated light, (3) cease calling for the deluge valves DV-1, 2 and 3 to be on, and (4) cease calling for each furnace's Flame Management System to shutdown that furnace. This enables the operator to stop the deluge water by resetting the deluge valves in the field; and, enables start-up

of the furnaces by putting each through a proper flame management system start-up sequence. (Note: The Loss of flow shutdown also must be bypassed for start-up.)

If a vapor detector is determined to be faulty during a shutdown, it may be bypassed in the same manner as described above. It should be left in the alarm state and not reset. When system reset, HS-3801, in the field is pressed, it will bypass that detector, thus not allowing it to vote on any subsequent occurrences as long as the detector is not reset. If at anytime later, it is decided that the detector is OK, it can be reset and it will be unbypassed.

Anytime one of the detectors on the furnace shutdown system is bypassed in the manner described above, then PLC III should sound the alarm bell and print a message every 4 hours to serve as a reminder to correct the situation. The bell can be silenced using the ACK button on OIP-6A. Each detector has a trouble circuit and a trouble alarm. Anytime the detector goes into the trouble mode, then the alarms are no longer functional and cannot cause the shutdown system to be armed or tripped by that detector. Whenever a detector goes into this mode, it will sound the alarm bell and print a message. The bell and message should be repeated every 8 hours as long as the trouble mode is active. The bell can be silenced by pressing the ACK button on OIP-6A.

- VI. The logic for the Furnace Shutdown System is provided by several devices. First, the Flame Management System logic, for each furnace, is provided by two programmable logic controllers located in cabinets in the field. Each cabinet contains one Modicon 484 PLC and a number of relays associated with the system. There is also one cabinet for each system that houses

all of the Fireye amplifiers for that furnace. The functional indicator lights and switches for each system are provided on a field mounted operators panel. Power is supplied to the FMS for each furnace by the Uninterruptable Power Supply (UPS). (#1 Furnace - UPS Circuit #CIP-6) (#2 Furnace - UPS Circuit #CIP-5). If this power is lost or turned off it will result in a furnace shutdown. If the cabinet doors on any of the field mounted cabinets are opened during furnace operation it will turn off power to that cabinet which will result in a shutdown of the associated furnace. There are also power switches on the outside of the FMS operators panel. Turning these off cuts power to the panel and will result in a furnace shutdown.

Second, the remainder of the shutdown system logic is provided by PLC III. The functional indicator lights and switches are provided, in the control room, on OIP-4 and OIP-6A. The power to these is supplied by the UPS (UPS Circuit # CIP-15). If the power is turned off, it will result in a shutdown of both furnaces. There is a message typewriter associated with PLC III. It provides prealarm and shutdown messages.

THE LIGHTS AND SWITCHES LOCATED ON OIP-6A, IN THE CONTROL ROOM, ARE RELATED TO THE OPERATION OF THE VAPOR DETECTOR INITIATED SHUTDOWN OF BOTH FURNACES. THESE ARE:

Vapor Detector Shutdown of Both Furnaces

Bypassed - (HI-6AL4). This red indicating lamp on aluminum mounting, will come on flashing anytime the bypass of the vapor detector inputs to the furnace shutdown system occurs. This occurs whenever the keyed bypass of DV-2 (Detectors 6A-1 through 6A-8) or DV-3 (Detectors 6A-9 through 6A-12) is manually initiated. The operation of either of these bypass switches will also cause the system bypass light to come on flashing. This light

will come on and blink at noticeable rate until such time as the bypass is removed. The light is provided to clearly indicate to the operators that the vapor detector initiated shutdown of the furnaces is bypassed and to serve as a reminder not to leave it this way. This bypass in no way affects the low flow shutdown of either furnace or a trip of either furnace by its respective flame management system. This bypass does not affect HS-3800 or HS-3905 operation. These will still cause a shutdown of both furnaces if either is pressed.

Vapor Detector Shutdown of Both Furnaces

Armed - (HI-3801). This amber light in an aluminum mounting is used to indicate that the "first vote" by a vapor detector for furnace shutdown, has occurred. It will come on flashing when the first vote occurs. The audible alarm (bell) will occur as a result of the corresponding vapor detector reaching the 40% LFL. Pressing the acknowledge pushbutton on OIP-6A will silence the bell and cause the armed light to go constant on. This is a signal to the operator that a shutdown of the furnaces due to a possible vapor cloud is eminent. A message is printed that the system is armed.

Vapor Detector Shutdown of Both Furnaces

Trip Initiated - (HI/HS-3800). This red indicator light with an integral pushbutton on a red aluminum mounting is used to indicate that a trip has been initiated by (1) the vapor detectors, (2) the pressing of the integral pushbutton, or (3) pressing the field mounted pushbutton. The pressing of this button causes the same things to occur as the auto system. These are: (1) Trip the natural gas to both furnaces, (2) Trip the snuffing steam of both furnaces and (3) Trip the deluge valve DV-1, DV-2, DV-3. Pressing this button will cause a message to occur. If the trip is manually

initiated the light will come on with no alarm but a message will be printed. If the trip is automatically initiated, the light will come on flashing, the bell will sound and a message be printed. The bell can be silenced by pressing the ACK button on OIP-6A. This button is still functional even if one or both of the related keyed bypasses are in the bypass position. The reset of this system can be done only from the field using the reset button HS-3801. When the reset is pressed, the trip initiated light will go out. When the trip initiated light goes on, the armed light will go off.

Vapor Detector Shutdown of Both Furnaces

All Flames Out - (HI-3802). This red indicator light on an aluminum mounting is used to feedback from the field to the operator that the trip of both furnaces has been accomplished. This light is activated by a signal from the FMS that identifies when all flame scanners in both furnaces see no fires and, both the pilot and main gas valves are closed on each. This light will come on flashing and cause an audible alarm. The audible may be silenced and the light go constant on, when the ACK button is pressed. This alarm also serves to identify whenever the FMS causes a shutdown to occur. In this case the shutdown is initiated in the field, so the trip initiated light will not be on.

No. 1 EDC Furnace Snuffing Steam

Run/Trip - (HS-3810). This switch is used to manually trip the snuffing steam valves to #1 EDC cracking furnace. Anytime a trip is manually initiated it will cause the associated light to come on constant and a message to be printed. The light will stay constant on until the switch is moved to the run position. This switch is a red knob on an aluminum mounting.

No. 1 EDC Furnace Snuffing Steam

Trip Initiated - (HI-3810). This red light on an aluminum mounting will operate as described above. In addition it will come on anytime a snuffing steam trip is initiated by a vapor detector initiated shutdown of the furnaces. In this case it will come on constant and stay on as long as the shutdown system calls for it. The snuffing steam may be stopped by manually closing block valves at the control stations. In order to get the shutdown system to stop calling for it, the reset button located on the analyzer shelter in the furnace area must be pressed.

No. 2 EDC Furnace Snuffing Steam

Run/Trip - (HS-3860). This switch is used to manually trip the snuffing steam valves to #2 EDC cracking furnace. Anytime a trip is manually initiated it will cause the associated light to come on constant and a message to be printed. The light will stay constant on until the switch is moved to the run position. This switch is a red knob on an aluminum mounting.

No. 2 EDC Furnace Snuffing Steam

Trip Initiated - (HI-3860). This red light on an aluminum mounting will operate as described above. In addition it will come on anytime a snuffing steam trip is initiated by a vapor detector initiated shutdown of the furnaces. In this case it will come on constant and stay on as long as the shutdown system calls for it. The snuffing steam may be stopped by manually closing block valves at the control stations. In order to get the shutdown system to stop calling for it, the reset button located on the analyzer shelter in the furnace area must be pressed.

Vapor Detector Bypass and Deluge Trips

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Furnace Floor DV-1 Trip - (HS-6AD1). This black pushbutton on an aluminum

mounting is used to trip the deluge underneath the furnace floor area. this system is also activated by heat activated devices or the Furnace Shutdown System on vapor detector initiation. It is not tripped by vapor detectors alone. There is no visual or audible alarm associated with this pushbutton. The alarm is accomplished as described in item 2 of OIP-6A write-up. A message does print out whenever the button is pressed.

Vapor Detector Bypass and Deluge Trip Switch

Furnace Area DV-2/SD Run/Bypass - (HS-6AB2). This two position key switch mounted on an aluminum mounting is used to bypass the input of vapor detectors 6A-1 through 6A-8. This is a key switch since it also results in the Furnace Vapor Detector Shutdown System being partially bypassed. It causes indicator lights to be activated as described in in items 4 and 8 of OIP-6A write-up. The key can only be withdrawn when the switch is in the run position. Whenever the key is in the bypass position it prevents the vapor detector from auto trip of DV-2 or "voting" in the Furnace Shutdown System. A message will be printed anytime this switch is put to bypass.

Vapor Detector Bypass and Deluge Trip Switch

Furnace Area DV-2 Trip - (HS-6AD2). This black pushbutton on an aluminum mounting is used to manually trip DV-2, the furnace area deluge. This is the only function it serves. It is still functional even if the keyed bypass described in the Furnace Area DV-2/SD Run/Bypass above, is in the bypass state. The alarming of this function is handled as described in item 2 of OIP-6A write-up. A message will be printed whenever the button is pressed.

Vapor Detector Bypass and Deluge Trip Switch

H₂O Shield/Refrig. DV-3/SD Run/Bypass - (HS-6AB3). This key switch functions the same as described in Furnace Area DV-2/SD Run/Bypass above, except that it applies to DV-3 and vapor detectors 6A-9 through 6A-12. The mounting is aluminum.

Vapor Detector Bypass and Deluge Trip Switch

H₂O Shield/Refrig. DV-3 Trip - (HS-6AD3). This black pushbutton on an aluminum mounting functions the same as described in Furnace Area DV-2 Trip above, except that it acts on DV-3.

THE LIGHTS AND SWITCHES LOCATED ON OIP-4 IN THE CONTROL ROOM, ARE RELATED TO THE OPERATION OF THE LOW FURNACE FEED FLOW SHUTDOWN OF EACH FURNACE. THESE ARE:

No. 1 EDC Furnace

Low Flow Run/Bypass - (HS-3816). This key switch on an aluminum mounting is used to bypass the low flow shutdown of #1 Furnace. When this switch is placed in the bypass position, it prevents an automatic shutdown of #1 Furnace due to the low flow voting system. The switch does not prevent a manual trip using HS-3809 trip initiated switch, a vapor detector initiated trip, a trip initiated by HS-3800 or HS-3905 or a trip by the flame management system for #1 Furnace. When the switch is placed in the bypass position its companion light, HI-3816, will come on and blink at a noticeable rate. A message is printed on PLC III typewriter.

No. 1 EDC Furnace

Low Flow Bypass - (HI-3816). This red indicator light on an aluminum mounting functions in association with the keyed bypass switch HS-3816, as described above.

No. 1 EDC Furnace

Start-up Bypass - (HI/HS-3814). This red indicator light with an integral pushbutton in an aluminum mounting is used to initiate a start-up bypass and so indicate. When the button is pressed a start-up bypass will begin. The red indicator light will come on constant and the PLC III message typewriter will print a message. When start-up bypass is initiated it prevents the two flow transmitter signals for each pass on #1 Furnace from causing a shutdown. The TMT is not affected by start-up bypass and if either should go into a high alarm state during start-up, it will cast its vote and arm the shutdown system. The two flows on each pass will remain bypassed for 1 hour. By the end of the hour, both flows on each pass must be established. If any one is not, then when the bypass time expires, it will cast its vote. If two, on the same pass, are not established, then the furnace will shutdown when the time expires. During the start-up bypass period, as the flows come up and go above the shutdown value, they will be automatically unbypassed by the shutdown system, after they have been above the trip value, continuously, for 1 minute.

The start-up bypass can only be used if the furnace is in a shutdown condition. Pressing during normal operation will have no effect. If the button is pressed during the start-up period a message will be printed indicating the time remaining and any signals that are not above the trip point. When the keyed bypass switch (HS-3816) is in the "Bypass" position pressing the start-up bypass will result in a message print of any parameters that are in the trip condition. Whenever a low flow shutdown has occurred the shutdown will seal itself and remain on until the start-up bypass is pressed. This will clear the shutdown signal from PLC III going to the Flame Management System.

The start-up bypass does not prevent the manual trip HS-3809, a vapor detector trip, a trip initiated by HS-3800 or HS-3905 or a trip by the Flame Management System for #1 Furnace.

No. 1 EDC Furnace

Flame Out All/One - (HI-3813/HI-3812). This two part red/amber indicating lamp in an aluminum mounting gives the status of the burners on #1 Furnace. The ALL portion of the light is red. It is turned on by a signal from the FMS, PLC-3813. This is done by PLC III monitoring a set of contacts in the FMS for #1 Furnace. When the contacts are open, the PLC III will indicate that all the fires are out. The FMS will open these contacts if (1) no fireye sees a flame, (2) the main fuel gas valve is closed and (3) the pilot gas valve is closed. This signal is a feedback from the field to the operator that a shutdown has occurred. When the all fires out light is turned on it will come on flashing and cause an audible and a message to be printed. When the ACK on #4 MOD III console is pressed, the audible is silenced and the light will go constant on. It will stay this way as long as the contacts PLC-3813 are open.

The ONE portion of the light is amber. It is turned on by a signal from the FMS, PLC-3812. This is done by monitoring a set of contacts in the FMS for #1 Furnace. When the contacts are open, the PLC III will indicate that one (or more) fires are out. The FMS will open these contacts if any one or more fireyes indicate that fires have gone out. When the One Flame Out Light is turned on it will come on flashing and cause an audible and a message to be printed. When the ACK on #4 MOD III console is pressed, the audible is silenced and the light will go constant on. The contact (PLC-3812) in the FMS may be closed, to clear the alarm light (HI-3812),

even if the burner or burners are not relit. This can be done by pressing the reset on the FMS operators panel in the field.

No. 1 EDC Furnace

Low Flow Armed - (HI-3804). This amber lamp in an aluminum mounting is used to indicate when one of the trip initiators (FT-3011, FT-3016, FT-3012, FT-3017, TE-3816, TE-3618) has cast a vote to shutdown. This light will come on flashing, cause an audible alarm and print a message. The audible may be silenced and the light go constant on by pressing the ACK on #4 MOD III console. The only way to disarm the system and cancel the vote, is to return the signal, that cast the vote to a normal state. At that point the light will go out. This light comes on immediately in the event that a flow has cast the vote, even though there is a 30 second delay on the trip action from these. The message prints immediately also. Even if both flow meters on a pass go low, and cast votes at the same time, the armed light and the messages print immediately. This is necessary so that the operator will have a chance to take corrective action. Then, 30 seconds later, if no corrections are made, the trip will occur.

No. 1 EDC Furnace

Trip Initiated - (HS/HI-3809). This red indicator lamp with an integral pushbutton on a red aluminum mounting is used to indicate the status of the low Flow initiated shutdown of #1 Furnace. The integral pushbutton is used to manually initiate a shutdown of #1 Furnace.

The light will be on anytime the system is calling for a trip of the #1 Furnace. The system will automatically call for a shutdown when one of the initiators cast a second vote (after a 30 second delay if the initiator was a flow). When this occurs the lamp will come on flashing, the audible alarm

will sound and a message will be printed. The audible is silenced by pressing the ACK on #4 MOD III console. The system will call for a shutdown when the integral pushbutton is pressed. When this occurs, the lamp will come on constant and a message will be printed.

The pushbutton is always functional even if the start-up bypass (HS-3816) or the keyed bypass (HS-3814) are in the bypass state.

The indicator lamp HI-3809 also acts as a status indicator for the Low Flow initiated system. Whenever the system is calling for a shutdown, even when in the start-up bypass or keyed bypass mode, the lamp will be on. It will automatically go off whenever the shutdown has cleared. The initiators that are causing the shutdown to be initiated can be identified by pressing the start-up bypass switch, HS-3816, when in either of the bypass modes just described.

Whenever the trip initiated light comes on, the armed light should go off.

THE LIGHTS AND SWITCHES FOR THE LOW FLOW INITIATED SHUTDOWN OF #2 FURNACE ARE ALSO LOCATED ON OIP-4. THE FUNCTION OF THESE IS EXACTLY THE SAME AS THAT DESCRIBED FOR THE CORRESPONDING LIGHTS AND SWITCHES ON #1 FURNACE. THESE LIGHTS AND SWITCHES ARE:

No. 2 EDC Furnace Low Flow Run Bypass (HS-3866)

No. 2 EDC Furnace Low Flow Bypass (HS-3866)

No. 2 EDC Furnace Start-up Bypass (HI/HS-3864)

No. 2 EDC Furnace Flame Out ALL/ONE (HI-3863/HI-3862)

No. 2 EDC Furnace Low Flow Armed (HI-3854)

No. 2 EDC Furnace Trip Initiated (HS/HI-3859)

THE LIGHTS AND SWITCHES LOCATED IN THE FIELD ON THE FLAME MANAGEMENT SYSTEM OPERATORS PANEL ARE RELATED TO ITS OPERATION. THESE ARE DESCRIBED AS FOLLOWS:

#1 Furnace FMS:

Furnace Start

HS-500 is used to initiate purge time on start-up of furnace. Other items that must be permissive are all dampers fully open, all supervisory valves closed, main gas double block & bleed closed and pilot gas supply valve closed.

Pilot gas valve open - L-572 - light is on when the pilot gas valve is open.

All gas off - L-505 - light is on when all supervisory valves are closed and the main fuel gas double block & bleed is closed and the pilot gas valve is closed.

Furnace off light - L-506 - light is on when the main gas double block & bleed is closed and when the pilot gas is closed and no flame detector sees any fire, pilot or main burner.

All dampers fully open - L-509 - light is on when the stack dampers and all 6 plenum dampers are fully open.

Damper closed - L-510 - light comes on anytime a damper, stack or plenum goes fully closed. After a 10 second delay this will result in a furnace shutdown. The light comes on immediately upon damper closing.

Purge on - L-501 - light comes on when the start button is pressed (other conditions permissive) and goes out at the end of the purge time.

Purge OK/Hot Furnace - L-504 - light comes on at the end of the purge time. The furnace start button must be pressed to get this light on. It will come on immediately if the furnace is hot. If the furnace is not hot, it will come on at the end of the 5 minute purge time.

OK to Light - L-502 - light comes on after the main pilot block valve is manually armed (provided it has a permissive circuit to arm). This light will stay on as long as the main pilot valve is open. The light will go out on a shutdown at which point the main pilot valve also closes.

Vent Valve Closed - L-508 - light is on when the vent valve is closed. This light serves as a reminder that the manual vent valve must be closed prior to start-up.

#1 to #28 Burner On - BL-A001 to BL-A028 - lights. These lights come on whenever the associated fireye sees a flame (pilot or main burner).

Fuel gas on - L-507 - light comes on when the main gas valve, XV-3803, is opened.

Trip Switch, HS-506, is mounted on the FMS operators panel and is used by the FMS to initiate a trip of #1 Furnace.

Burner #1 to #28 Ignitor Switch, HS-A101 to HS-A128, is used by the FMS to initiate a pilot ignition sequence.

Alarm Reset Switch, HS-001, is mounted on the FMS operators panel. It is used to silence the audible alarm for #1 Furnace and to reset the flame failure alarm PLC-3812 that is sent to the control room.

Operator Panel, Low Purge Pressure - L-18 - indicator lamp for the operators panel. It comes on and stays on whenever PSL-18 indicates a low pressure.

Fireye Amplifier Cabinet Low Purge Pressure indicator lamp - L-19A is mounted on the operators panel. L-19B is mounted on the amplifier cabinet. These come on and stay on whenever PSL-19 indicates a low pressure.

Controller Cabinet #1 Low Purge Pressure indicator lamp - L-20A - is mounted on the operator panel. L-20B is mounted on the Controller Cabinet #1. These come on and stay on whenever PSL-20 indicates a low pressure.

Controller Cabinet #2 Low Purge Pressure indicator lamp - L-21A - is mounted on the operator panel - L-20B - is mounted on the Controller Cabinet #2. These come on and stay on whenever PSL-21 indicates a low pressure.

#1 to #28 Supervisory Valve Open - ZL-A051 to ZL-A078 - indicator lamp. These lights come on whenever the associated supervisory valves are in the open position.

THE #2 FURNACE FMS LIGHTS AND SWITCHES FUNCTION IN EXACTLY THE SAME MANNER AS THOSE DESCRIBED ABOVE FOR #1 FURNACE.

VII. Start-up

In order to start-up one or both furnaces after a shutdown. It is necessary to carry the furnace through the purge and light sequence that is controlled by the Flame Management System (FMS). It is first necessary that any shutdown request from PLC III in the control room be cleared. This is done by resetting any alarming vapor detectors (unless they are determined to be faulty) and pressing the reset pushbutton, HS-3801, in the field. The

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start-up bypass switch (HS-3814) on OIP-4 should be pressed. This should only be done at a point where it will be less than 1 hour before EDC feed flow is to be started to the respective furnace. The master bypass of low flow (HS-3816 or HS-3866) or vapor detector shutdown (HS-6AB2 & HS-6AB3) should only be used for maintenance purposes.

Prior to pressing the start-up bypass on OIP-4 the furnace should be put into a status that will allow the purge to be started immediately after the start-up bypass is initiated. For #1 Furnace this is done by: (1) Opening all dampers on the furnace to the wide open position. This will be confirmed by the "All Dampers Open" light, L-509, on the FMS operators panel in the field, (2) Closing all FM block valves on the gas lines to each burner. This is confirmed by the "All Gas Off" light, L-505, on the FMS operators panel. It is also necessary that the main fuel gas block, XV-3832, be closed to get L-505 to come on. If it does not light, then the supervisory valve open lights, ZL-051 to ZL-078, should be checked to see which is open (be sure all bulbs are good). If no valve is open then the position switch, ZSL-3803 and ZSL-3832, should be checked. Lights L-572 and L-507 should be off. If one is not, then this is preventing start. (3) Fuel gas should be available up to the inlet side of the main gas double block & bleed (PCV-3425 should be in operation and properly adjusted). (4) The furnace feed pumps should be on and the flow control valves adjusted to supply the desired start-up flowrate. The flow will be returning to the Heavies still reflux tank via the start-up line rather than going through the furnace. The FF economizer should not have any product still bottoms flow. (5) The flame detector sensor at each burner should be checked and the lenses cleaned. The ignitors for each burner should be cleaned and dried. (6) The fuel gas flow controller

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in the control room should be adjusted so that it is calling for zero fuel gas flow. (7) The fuel gas adjustment valves to each chamber of the furnace should be open. (8) The bypass around the fuel gas control valve, FV-3025, should be sealed closed.

After the above conditions are satisfied and the start-up bypass on OIP-4 is initiated there is one hour to ignite the burners and get furnace fuel flow established.

The first step is to press the start button, HS-500, on the FMS operators panel. Purge On light, L-501, should come on. The purge should run for 5 minutes. If the furnace is not (above 1400°F) then the Purge OK/ Hot Furnace light, L-504, should come on and the purge step is bypassed. If not, it will come on at the end of the purge time. The furnace fire-box should now be checked at several points, with an explosion meter to ensure that it is free of flammable vapors. The pilot gas supply valve may now be opened. This will supply gas up to each pilot solenoid valve. The "Pilot Gas On" light, L-572, should come on at this point. The pilot gas bleed valve, XV-3833, will close 5 seconds after the pilot gas valve is opened.

The ignition sequence for the pilot should now be started. This is done by pressing the ignition pushbutton, HS-A101 to HS-A128. The pilots will attempt to light for 15 seconds. Any that fail will be locked out for 50 seconds. If all fail, the pilot gas supply will trip, and the purge sequence will have to be redone in order to open it. Preferably all pilots should be lit before any main burners. After the pilots are lit the main fuel gas supply valve, XV-3803, may be opened. This will be indicated by L-507, Fuel Gas On light. The bleed valve will have closed after the first pilot was indicated to be on.

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In order to light main burners, the board mounted fuel gas controller should be asking for the valve to be closed. This will cause the signal selector in the field to select the signal from the field mounted fuel gas pressure controller. The pressure controller, PIC-3476, should be set for a low pressure so that the burners will fire at a low rate. Once the pilot for a given burner is on, then the maxon valve for that main burner may be opened. After the maxon is opened the main burner may be lit by slowly opening the supervisory valve. The main flame should come on. When the supervisory valve is opened, it starts a timer that causes the pilot to go off in 10 seconds. The main flame must be established by this time and the fireye detecting it in order to keep the burner on. If it is not, then the maxon will close. The pilot is turned off at the end of the 10 second trial period.

As each subsequent burner is lit, the pressure controller should maintain the fuel gas flow, by pressure control, such that the main flames are at a steady, low firing rate. After all burners are lit, the control of FV-3025 may be taken using the board mounted controller. The firing may be brought up by simply opening FIC-3025. This should cause the signal selector to choose FIC-3025 when its signal becomes greater than the PIC-3426. EDC feed flow should be started to the furnace before the firing rate is increased.

Feed flow is started by opening the downstream block valve of the control station, thus allowing the feed to start into the furnace and closing the valve in the start-up line. The low flow shutdown should clear at this point. If it does, the trip initiated light on OIP-4 should go out. This serves as a shutdown system status indicator. Pressing it after the

start-up bypass is in effect will result in a message print of any parameter that has not cleared its trip valve and may still result in a shutdown. The Product still bottoms flow should be put through the FF economizer. Fuel gas flow to the furnace should be increased to bring up the crossover temperature to vaporization. EDC feed flow and fuel gas flow should be brought up together to the desired flowrate and eventually to the desired conversion. Heat-up should be restricted to a rate of 90°F/hour for the flue gas temperature if the refractory has cooled during the outage or 50°F/hour for the process outlet temperature.

Decoking Start-up

When the furnaces are to be decoked, there will not be any feed flows. For this reason the Low flow shutdown feature will have to be bypassed using the keyed bypass switch. During this operation overheating of the tubes due to loss of flow can still occur. If a loss of flow does occur, it will be necessary for the operator to manually trip the furnace. There are sufficient flow and temperature alarms in the control room for the operator to do this. The Flame Management and vapor detector shutdown features will still be active.

The start-up sequence is the same as described above with the exception that no EDC furnace feed flow is established. In its place, decoking steam flow is started instead.

- VIII. The PLC III will generate a number of alarm messages to warn of parameters moving toward shutdown conditions and to record the Status of the system.

These are:

FT-3011 #1 Furnace #1 Pass Feed Flow Low @ 25 gpm

FT-3011 #1 Furnace #1 Pass Feed Flow Low Trip @ 15 gpm

FT-3016 #1 Furnace #1 Pass Feed Flow Low @ 25 gpm

FT-3016 #1 Furnace #1 Pass Feed Flow Low Trip @ 15 gpm
FT-3012 #1 Furnace #2 Pass Feed Flow Low @ 25 gpm
FT-3012 #1 Furnace #2 Pass Feed Flow Low Trip @ 15 gpm
FT-3017 #1 Furnace #2 Pass Feed Flow Low @ 25 gpm
FT-3017 #1 Furnace #2 Pass Feed Flow Low Trip @ 15 gpm
FT-3061 #2 Furnace #1 Pass Feed Flow Low @ 25 gpm
FT-3061 #2 Furnace #1 Pass Feed Flow Low Trip @ 15 gpm
FT-3066 #2 Furnace #1 Pass Feed Flow Low @ 25 gpm
FT-3066 #2 Furnace #1 Pass Feed Flow Low Trip @ 15 gpm
FT-3062 #2 Furnace #2 Pass Feed Flow Low @ 25 gpm
FT-3062 #2 Furnace #2 Pass Feed Flow Low Trip @ 15 gpm
FT-3067 #2 Furnace #2 Pass Feed Flow Low @ 25 gpm
FT-3067 #2 Furnace #2 Feed Flow Low Trip @ 15 gpm

HS-3809 #1 Furnace Manual Trip Initiated

HS-3859 #2 Furnace Manula Trip Initiated

#1 Furnace Low Flow Shutdown Armed

#2 Furnace Low Flow Shutdown Armed

TE-3616 #1 Furnace #1 Pass Radiant TMT @ Floor High 1500°F
TE-3616 #1 Furnace #1 Pass Radiant TMT @ Floor High Trip 1550°F
TE-3618 #1 Furnace #2 Pass Radiant TMT @ Floor High 1500°F
TE-3618 #1 Furnace #2 Pass Radiant TMT @ Floor High Trip 1550°F
TE-3666 #2 Furnace #1 Pass Radiant TMT @ Floor High 1500°F
TE-3666 #2 Furnace #1 Pass Radiant TMT @ Floor High Trip 1550°F
TE-3667 #2 Furnace #2 Pass Radiant TMT @ Floor High 1500°F
TE-3667 #2 Furnace #2 Pass Radiant TMT @ Floor High Trip 1550°F

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#1 Furnace Low Flow Shutdown Trip Initiated

#2 Furnace Low Flow Shutdown Trip Initiated

#1 Furnace Low Flow Shutdown Trip Bypassed

#2 Furnace Low Flow Shutdown Trip Bypassed

PLC-3813 #1 Furnace All Fires Out

PLC-3863 #1 Furnace All Fires Out

#1 Furnace Start-up Bypass Started

#2 Furnace Start-up Bypass Started

#1 Furnace Start-up Bypass Time Remaining _____ min. Parameters in Trip -

#1 Pass _____ #2 Pass _____

#2 Furnace Start-up Bypass Time REmaining _____ min. Parameters in Trip -

#1 Pass _____ #2 Pass _____

#1 Furnace Burner Failures PLC-3812

#2 Furnace Burner Failures PLC-3862

6A-1 Vapor Detector 40% LFL High

6A-2 Vapor Detector 40% LFL High

6A-3 Vapor Detector 40% LFL High

6A-4 Vapor Detector 40% LFL High

6A-5 Vapor Detector 40% LFL High

6A-6 Vapor Detector 40% LFL High

6A-7 Vapor Detector 40% LFL High

6A-8 Vapor Detector 40% LFL High

6A-9 Vapor Detector 40% LFL High

6A-10 Vapor Detector 40% LFL High

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6A-11 Vapor Detector 40% LFL High

6A-12 Vapor Detector 40% LFL High

Note: The vapor detector high alarms are redundant with the deluge system alarms. These alarms are listed here for reference only. They need only be generated by one system.

#1 and #2 Furnace Vapor Detector Shutdown Armed

#1 and #2 Furnace Vapor Detector Shutdown Initiated

HS-3800/HS-3905 #1 and #2 Furnace Shutdown Manually Initiated

#1 and #2 Furnace Vapor Detector Shutdown Disarmed

Vapor Detector ____ Not Reset (Repeat every 4 hours)

Vapor Detector in trouble mode (Repeat every 8 hours)

Vapor Detectors 6A-1 to 8 Bypassed to Furnace Shutdown System

Vapor Detectors 6A-9 to 12 Bypassed to Furnace Shutdown System

#1 Furnace Snuffing Steam Manually Initiated

#2 Furnace Snuffing Steam Manually Initiated

In addition to the PLC III generated alarms there are a number of back-up or redundant alarms generated by the Computer/MOD III system. There are also a number of alarms and indications developed by the Computer/MOD III that do not have trip associated with them but are none-the-less very necessary for the safe operation of the furnaces. These are:

MOD III

FT-3011 #1 Furnace #1 Pass Feed Flow Deviation $\pm$ 2%

FT-3011 #1 Furnace #1 Pass Feed Flow Output Low = 5%

FT-3012 #1 Furnace #2 Pass Feed Flow Deviation $\pm$ 2%

FT-3012 #1 Furnace #2 Pass Feed Flow Output Low = 5%

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FT-3061 #2 Furnace #1 Pass Feed Flow Deviation $\pm$ 2%
FT-3061 #2 Furnace #1 Pass Feed Flow Output Low = 5%
FT-3062 #2 Furnace #2 Pass Feed Flow Deviation $\pm$ 2%
FT-3062 #2 Furnace #2 Pass Feed Flow Output Low = 5%

FT-3025 #1 Furnace Natural Gas Flow Deviation $\pm$ 2%
FT-3025 #1 Furnace Natural Gas Flow Output High -98%

FT-3075 #2 Furnace Natural Gas Flow Deviation $\pm$ 2%
FT-3075 #2 Furnace Natural Gas Flow Output High -98%

Computer Alarms

FT-3016 #1 Furnace #1 Pass Feed Flow Low @ 10 gpm
FT-3017 #1 Furnace #2 Pass Feed Flow Low @ 10 gpm
FT-3066 #2 Furnace #1 Pass Feed Flow Low @ 10 gpm
FT-3066 #2 Furnace #2 Pass Feed Flow Low @ 10 gpm

PT-3411 #1 Furnace #1 Pass Inlet Pressure High 280 PSIG
PT-3412 #1 Furnace #2 Pass Inlet Pressure High 280 PSIG
PT-3461 #2 Furnace #1 Pass Inlet Pressure High 280 PSIG
PT-3462 #2 Furnace #2 Pass Inlet Pressure High 280 PSIG

PT-3436 #1 Furnace #1 Pass Outlet Pressure High 150 PSIG
PT-3436 #1 Furnace #1 Pass Outlet Pressure Low 100 PSIG
PT-3437 #1 Furnace #2 Pass Outlet Pressure High 150 PSIG
PT-3437 #1 Furnace #2 Pass Outlet Pressure Low 100 PSIG
PT-3486 #2 Furnace #1 Pass Outlet Pressure High 150 PSIG
PT-3486 #2 Furnace #1 Pass Outlet Pressure Low 100 PSIG
PT-3487 #2 Furnace #2 Pass Outlet Pressure High 150 PSIG
PT-3487 #2 Furnace #2 Pass Outlet Pressure Low 100 PSIG

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PT-3420 #1 Furnace Draft Pressure High 0.0" H₂O

PSL-3423 #1 Furnace Natural Gas Pressure Low - 0.5 PSIG

PSH-3424 #1 Furnace Natural Gas Pressure High - 15 PSIG

PT-3470 #2 Furnace Draft Pressure High 0.0" H₂O

PSL-3472 #2 Furnace Natural Gas Pressure Low - 0.5 PSIG

PSH-3474 #2 Furnace Natural Gas Pressure High - 15 PSIG

TE-3611 #1 Furnace Stack Temperature High 450°F

TE-3661 #2 Furnace Stack Temperature High 450°F

TE-3620 #1 Furnace South Chamber Bridgwall Temperature High 1600°F

TE-3621A #1 Furnace Center Chamber Bridgwall Temperature High 1600°F

TE-3622 #1 Furnace North Chamber Bridgwall Temperature High 1600°F

TE-3670 #2 Furnace South Chamber Bridgwall Temperature High 1600°F

TE-3671A #2 Furnace Center Chamber Bridgwall Temperature High 1600°F

TE-3672 #2 Furnace North Chamber Bridgwall Temperature High 1600°F

TE-3628 #1 Furnace #1 Pass Radiant Section TMT High 1500°F

TE-3632 #1 Furnace #2 Pass Radiant Section TMT High 1500°F

TE-3678 #2 Furnace #1 Pass Radiant Section TMT High 1500°F

TE-3680 #2 Furnace #2 Pass Radiant Section TMT High 1500°F

TE-3636 #1 Furnace #1 Pass Outlet Temperature High 1000°F

TE-3637 #1 Furnace #2 Pass Outlet Temperature High 1000°F

TE-3686 #2 Furnace #1 Pass Outlet Temperature High 1000°F

TE-3687 #2 Furnace #2 Pass Outlet Temperature High 1000°F

Computer Alarms when in Decoking Mode

FT-3021 #1 Furnace #1 Pass Decoking Steam Flow Low 3000 #/hr

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FT-3021 #1 Furnace #1 Pass Decoking Steam Flow High 13,500 #/hr
FT-3022 #1 Furnace #2 Pass Decoking Steam Flow Low 3,000 #/hr
FT-3022 #1 Furnace #2 Pass Decoking Steam Flow High 13,500 #/hr

FT-3071 #2 Furnace #1 Pass Decoking Steam Flow Low 3,000 #/hr
FT-3071 #2 Furnace #1 Pass Decoking Steam Flow High 13,500 #/hr
FT-3072 #2 Furnace #2 Pass Decoking Steam Flow Low 3,000 #/hr
FT-3072 #2 Furnace #2 Pass Decoking Steam Flow High 13,500 #/hr

FT-3030 #1 Furnace #1 Pass Decoking Air Flow Low 3,000 #/hr
FT-3030 #1 Furnace #1 Pass Decoking Air Flow High 5,500 #/hr
FT-3031 #1 Furnace #2 Pass Decoking Air Flow Low 3,000 #/hr
FT-3031 #1 Furnace #2 Pass Decoking Air Flow High 5,500 #/hr

FT-3080 #2 Furnace #1 Pass Docoking Air Flow Low 3,000 #/hr
FT-3080 #2 Furnace #1 Pass Decoking Air Flow High 5,500 #/hr
FT-3081 #2 Furnace #2 Pass Decoking Air Flow Low 3,000 #/hr
FT-3081 #2 Furnace #2 Pass Docoking Air Flow High 5,500 #/hr

TE-3612 #1 Furnace #1 Pass Convection Section TMT High 750°F
TE-3614 #1 Furnace #2 Pass Convection Section TMT High 750°F
TE-3662 #2 Furnace #1 Pass Convection Section TMT High 750°F
TE-3664 #2 Furnace #2 Pass Convection Section TMT High 750°F

IX. The basis for several Furnace SDS valves follows:

TE-3621B/TE-3671B - Purge bypass temperature of 1400°F was chosen based on reference to this value in the literature. The criteria should be that the temperature be above the auto ignition temperature of CH₄ (or #2 Fuel oil if it is used).

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FT-3011, 3016, 3012, 3017, 3061, 3066, 3062 and 3067 - Low flow trip of 15 gpm was chosen by the flowmeter range. The desired case is loss of flow, but a value must be picked at which the flowmeter is likely to give a reasonably good approximate value for flowrate. The orifice meter is only accurate down to 25 gpm at best, so at 15 gpm it is possible that the flow might actually be $\pm$ by a fair amount. The situation to be avoided is for the flow to get to essentially zero, in reality, and for the meter valve not to cause a trip. This should not be possible if 15 gpm is used for the meter value. The 30 second delay time on this is used to allow the operator to correct for small upsets and control loop problems. The 30 seconds comes from experience. It has proven not to have allowed much overheating, while at the same time it has been sufficient to correct problems. It is true that the furnace can be overheated and damaged even with feed flow above 25 gpm. This overheating can happen anytime there is an imbalance in feed and firing. The Loss of flow system is intended to cover the worst case of complete loss of feed.

TE-3616, 3618, 3666, 3668 - Radiant section TMT trip valves are based on providing a suitable margin above normal operation temperature for the alarm and trip, so long as the temperature and pressure under a worst case will not result in a tube rupture. The end of run, TMT can be as high as 1440°F so the alarm and trip are above this. The tube can safely operate up into the 1800°F range for short periods. Values of 1500°F alarm and 1550°F trip for these temperature are felt to meet these criteria.

The time delay of 10 seconds on the damper closed trip of the furnaces is to allow that the dampers be normally adjusted as a part of routine operation.

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PSL/PSH-3423 & 3473 - The valves of 0.5 PSIG low and 15 PSIG were selected to be outside the normal design operating range.

X. The following documents serve as references:

1. Loop alarm sheets for all loop numbers given above.
2. Loop sheets for all loop numbers given above.
3. PLC I/O Schedule Drawing No.
4. PLC III Ladder Listing Program Printout.
5. Flame Management System Controller #1 Ladder Listing Program Printout.
6. Flame Management System Controller #2 Ladder Listing Program Printout.
7. KTI Logic Diagram
8. KTI Elementary Diagram

XI. Troubleshooting

There is very little that can be done by an operator or instrument mechanic on the Furnace Shutdown System. This results from the fact that essentially all of the logic is handled by programmable logic controllers (PLC's).

The operator should first attempt to identify the problem. If the problem is a result of a faulty input signal, then an instrument man can correct it. If the problem appears to be the result of a logic failure then a computer technician is required to correct it.

The most likely input signal failures are:

Faulty position switch failures. These are all on the FM system and most are indicated by a lamp so that identification of the problem should be easy.

Flame detector failure. If a flame fails to light it is probably the Fireye detector. This usually can be corrected by cleaning the lense.

It may also be caused by a faulty ignitor.

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No. 91-1145

Low purge pressure. This is indicated by a local alarm and alarm light. The operator should first determine if the purge source has been lost. If it has not, then it could be a faulty pressure switch. These cannot be worked on while the furnace is in operation.

Faulty transmitter input to the Loss of Flow system. This can be easily identified by the operator since there are dual flow meters and the flow meters also go th the computer. The temperature trip also has other back-ups. If the faulty signal results in a system armed light the system should not be bypassed to prevent trip. The instrument should be repaired ASAP. Only while the mechanic is working on the faulty instrument should the keyed bypass be used.

Faulty Vapor detector signals. These can be identified by use of a portable vapor detector. If the detector is faulty, it should be left in the alarm state and an instrument mechanic should repair it ASAP.

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SL 012137

CAUSES OF SIGNAL LOSS IN CATALYTIC TYPE COMBUSTIBLE GAS SENSORS

Interfering or contamination gases or substances which may adversely affect proper operation of the instrument are as follows:

- A. Materials that may clog the pores of the flame arrestor thereby reducing the gas diffusion rate into the sensor are:
 - 1) Dirt and Oil
 - a. A dust cover should be installed to protect the flame arrestor whenever these conditions exit.
 - b. The dust cover can be cleaned as part of routine maintenance. Clean in an organic solvent using an ultrasonic bath.
 - 2) Corrosion Products.
 - a. This occurs when Cl_2 (chlorine) or HCl are present. A dust cover provides some protection.
 - b. Replace the dust cover as part of routine maintenance.
 - 3) Flame arrestor clogged during painting and house cleaning.
 - a. The sensor should be covered by a plastic bag. Remove the bag as soon as possible. Make this a check point in your maintenance procedures.
 - 4) Polymer formation in the flame arrestor.
 - a. This sometimes occurs where monomer vapors such as 1, 3 butadiene, styrene, isoprene, etc., are present.
- B. Substances that cover or tie up the active sites on the catalytic surface of the sensor's active element.

This occurs in the presence of volatile metal organics, gases, or vapors of hydrides, and volatile compounds containing phosphorous, boron, silicon, etc.

EXAMPLES:

lead tetraethyl
phosphine
diborane
silane
trimethyl chlorsilane
hydrogen fluoride
boron trifluoride
phosphate esters
silicone oils and greases
RTV silicone sealants

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SL 012138

- C. The catalytic metals are removed from the sensor's active elements.
- 1) Some substances react with the catalytic metal forming a volatile compound. This erodes the metal from the surface and, given sufficient exposure to these types of material, all or most of the metal catalyst can be removed from the surface of the sensor's active element.
 - 2) Halogens and halogen containing compounds are materials of this nature.
EXAMPLE:
Chlorine
Bromine
Iodine
Hydrogen chloride, bromide or iodide
Organic halides
Trichloroethylene
dichlorobenzene
vinyl chloride
freons
Halon 1301 (Bromotrifluoromethane)
 - 3) A brief exposure to one of these materials may increase the sensitivity of the sensor. This is usually a temporary effect as a result of etching the catalytic surface.
This is sometimes used as a means to activate a sensor that has a degraded signal.
THIS IS A PRACTICE THAT IS UNRELIABLE AND MAY GIVE A FALSE SENSE OF SECURITY.
- D. Extended exposure to high concentrations of combustible gases and air.
- 1) Extended exposure of a detector element to certain concentrations of combustible gases and/or air can introduce stress to the element that may seriously affect its performance, and therefore re-calibration should be carried out or the sensor replaced, or both, after an alarm due to an indication of a high concentration.
- E. The degree of damage to a sensor is a combination of the type of contaminant, its concentration in the ambient atmosphere and the length of time the sensor is exposed.
- 1) The loss of sensitivity is generally discovered when the sensor is calibrated. When this occurs, first ascertain whether the calibration has been correctly carried out, the calibration system is functioning properly, and the correct gas mixture is being used.
 - 2) The calibration schedule should reflect the probable exposure of the sensor to known conditions that affect the quality of sensor signal.
 - 3) When it is known that the sensor has been exposed to high concentrations of a poison, extended exposure to high concentrations of combustible gas/air mixtures, or other unusual conditions, it should be recalibrated at that time and a few days later to look for a significant shift in its sensitivity.

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APPENDIX III

7.0

SL 012140

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19.111111 1001
 20.101010 100
 1.10010101 10010101
 10010101 10010101

1 201
 2 203
 3 1016
 4 1101
 5 010
 6 101
 7 203
 8 200
 9 200
 10 252
 11 371
 12 501
 13 502
 14 502
 15 506
 16 604
 17 711
 18 711

19 711
 20 101010101 10010101
 21 101010101 10010101
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SL 012141

CONFIDENTIAL: Order

Subject to Protective District Court

of 14th Judicial No. 91-1145

CONFIDENTIAL: Order

Item	Unit	Quantity	Unit Price	Total
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3	100	100	1.00	100.00
4	100	100	1.00	100.00
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7	100	100	1.00	100.00
8	100	100	1.00	100.00
9	100	100	1.00	100.00
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28	100	100	1.00	100.00
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30	100	100	1.00	100.00
31	100	100	1.00	100.00
32	100	100	1.00	100.00
33	100	100	1.00	100.00
34	100	100	1.00	100.00
35	100	100	1.00	100.00
36	100	100	1.00	100.00
37	100	100	1.00	100.00
38	100	100	1.00	100.00
39	100	100	1.00	100.00
40	100	100	1.00	100.00
41	100	100	1.00	100.00
42	100	100	1.00	100.00
43	100	100	1.00	100.00
44	100	100	1.00	100.00
45	100	100	1.00	100.00
46	100	100	1.00	100.00
47	100	100	1.00	100.00
48	100	100	1.00	100.00
49	100	100	1.00	100.00
50	100	100	1.00	100.00

CONFIDENTIAL: Order

Subject to Protective District Court

Item	Unit	Quantity	Unit Price	Total	Item	Unit	Quantity	Unit Price	Total	Item	Unit	Quantity	Unit Price	Total	Item	Unit	Quantity	Unit Price	Total	Item	Unit	Quantity	Unit Price	Total
1	100	100	1.00	100.00	11	100	100	1.00	100.00	21	100	100	1.00	100.00	31	100	100	1.00	100.00	41	100	100	1.00	100.00
2	100	100	1.00	100.00	12	100	100	1.00	100.00	22	100	100	1.00	100.00	32	100	100	1.00	100.00	42	100	100	1.00	100.00
3	100	100	1.00	100.00	13	100	100	1.00	100.00	23	100	100	1.00	100.00	33	100	100	1.00	100.00	43	100	100	1.00	100.00
4	100	100	1.00	100.00	14	100	100	1.00	100.00	24	100	100	1.00	100.00	34	100	100	1.00	100.00	44	100	100	1.00	100.00
5	100	100	1.00	100.00	15	100	100	1.00	100.00	25	100	100	1.00	100.00	35	100	100	1.00	100.00	45	100	100	1.00	100.00
6	100	100	1.00	100.00	16	100	100	1.00	100.00	26	100	100	1.00	100.00	36	100	100	1.00	100.00	46	100	100	1.00	100.00
7	100	100	1.00	100.00	17	100	100	1.00	100.00	27	100	100	1.00	100.00	37	100	100	1.00	100.00	47	100	100	1.00	100.00
8	100	100	1.00	100.00	18	100	100	1.00	100.00	28	100	100	1.00	100.00	38	100	100	1.00	100.00	48	100	100	1.00	100.00
9	100	100	1.00	100.00	19	100	100	1.00	100.00	29	100	100	1.00	100.00	39	100	100	1.00	100.00	49	100	100	1.00	100.00
10	100	100	1.00	100.00	20	100	100	1.00	100.00	30	100	100	1.00	100.00	40	100	100	1.00	100.00	50	100	100	1.00	100.00

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No. 91-1145

SL 012143

CONFIDENTIAL:
Subject to Protective Order
Of 14th Judicial District Court
NO: 91-1145

APPENDIX IV

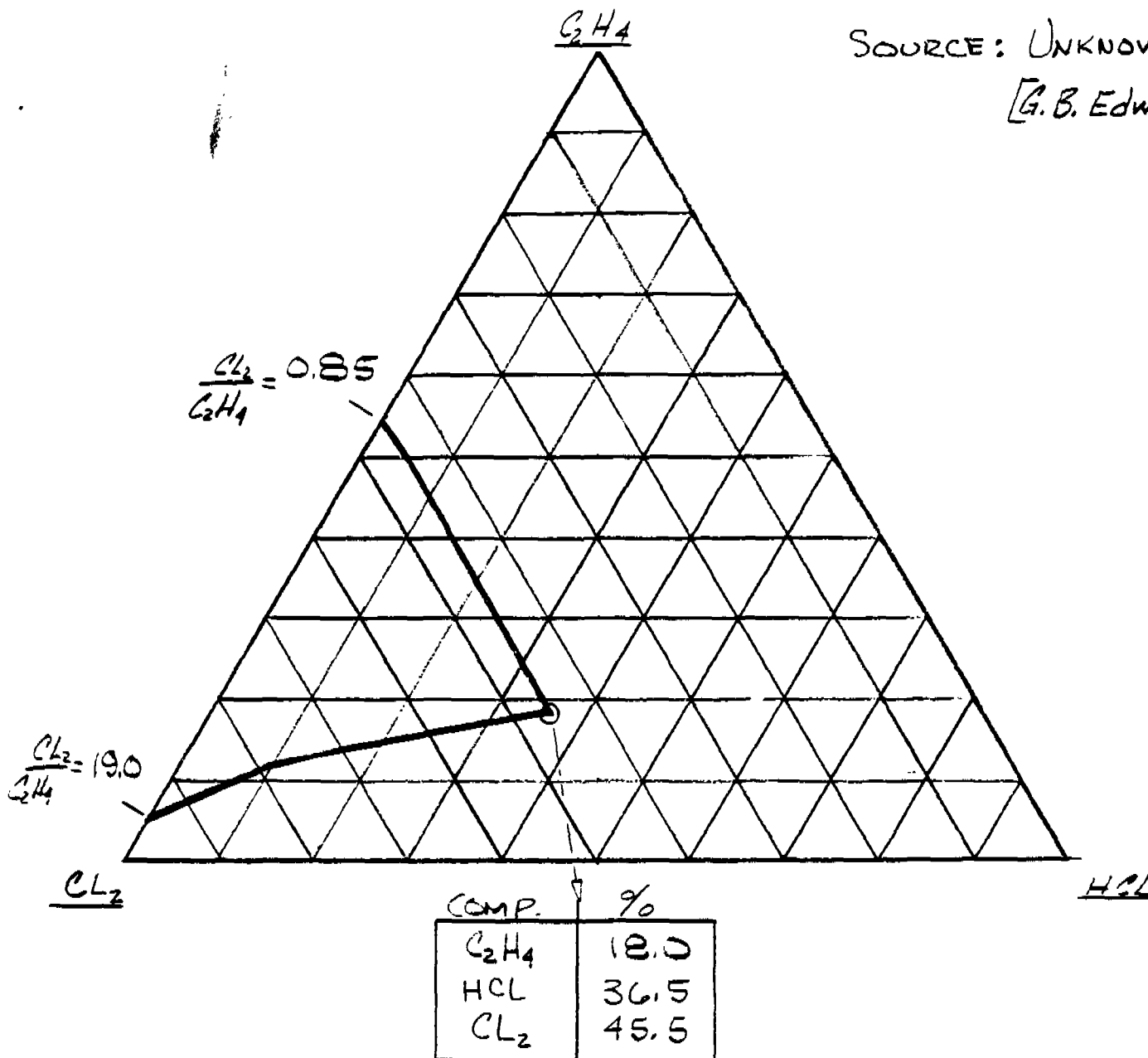
SL 012144

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 10/21/80
 Job VLM II - RELIABILITY STUDY, LEVEL III By P.A. KELLEY
 Subject OHC - LP Rx VENT, TERNARY DIAGRAM Checked By _____

EXPLOSIVE LIMITS: CL_2 , HCL , AND C_2H_4

SOURCE: UNKNOWN

[G.B. EDWARDS]



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 No. 91-1145

Client P.P.G. - LAKE CHARLES, LA. Ref. _____ Date 10/17/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By P.A. KELLEY
 Subject OPERATOR ACTION - FDT SUMMARY Checked By _____

<u>ACTION REQUIRED</u>	<u>FDT</u>	
	<u>EMERGENCY</u>	<u>STANDARD</u>
1. ACTION $\leq$ ONE MINUTE	0.9	0.2
2. " $\leq$ FIVE MINUTES	0.5	0.1
3. " $\leq$ TEN MINUTES	0.1	0.02
4. " $\leq$ THIRTY MINUTES	0.05	0.015

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SL 012147

PETROCON, INC.
ENGINEERS & DESIGNERS

CONFIDENTIAL
Subject to Protective Order
of 14th Judicial District Court
No. 01-148

P. O. Box 3971

Beaumont, Texas 77704

713/842-2417

May 15, 1980

PPG Industries, Inc.
P. O. Box 1000
Lake Charles, LA 70601

Attention: Walter Oglesby
Process Engineer

VCM II - RELIABILITY STUDY
LEVEL III

PETROCON JOB NO. P79.57

SUBJECT: GAS CHROMATOGRAPHIC
ANALYSIS BACK-UP
OXYGEN ANALYSIS

Gentlemen:

Attached is the ternary diagram explosive range for an OHC Reactor Vent System operating at maximum pressure (near 65 psia). As seen on Page 1D there is a large safe operating range, however, the increased ethylene costs warrant not operating with C_2H_4/HCL ratios much greater than design (0.483 Lb. $C_2H_4/Lb.$ HCL).

We recommend to alarm a feed condition of C_2H_4/HCL ratio of greater than 0.66. As seen on Page 1F the economic and safe operating range is limited to a smaller area.

In addition to this feed ratio alarm we recommend using the process gas chromatograph and it's output to alarm various ratios in the unit system. If a oxygen/HCL ratio of 0.0549 was alarmed this would represent a line shown on Page 1G. This would be a diversified backup to the oxygen analyzers. Alarm valves of C_2H_4/HCL ratios of greater than 0.483 and less than 0.67 in the vent system would limit the economic and safe operating range of the vent system to the shaded area shown on Page 1G.

If you think these suggestions warrant further consideration, please forward same to Byron. I will be happy to discuss this at your convenience.

Sincerely yours,

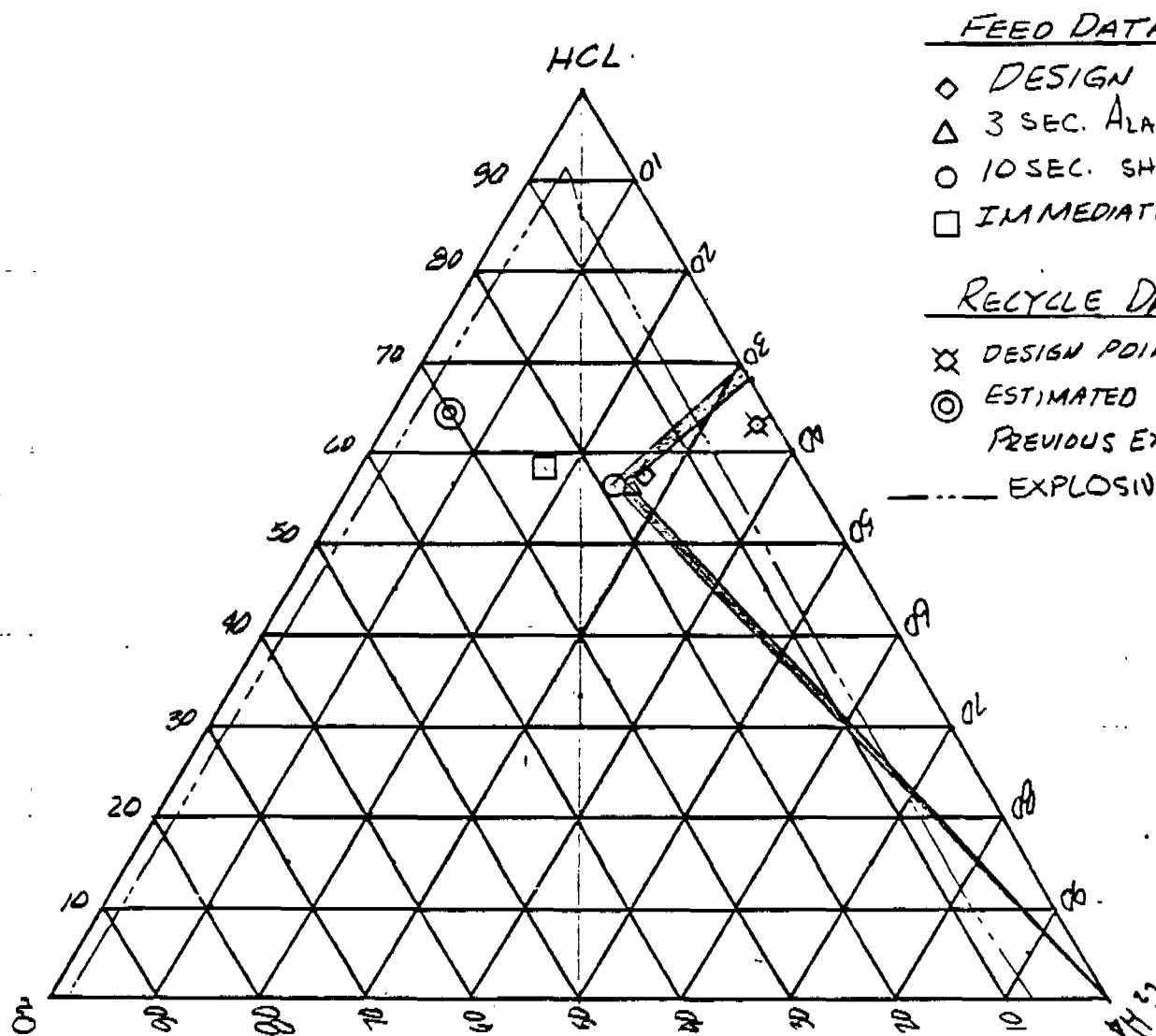
PETROCON, INC.
P. A. Kelley
P. A. Kelley
Project Engineer

PAK/dsh

Enclosures

SL 012148

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 5/12/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject OHC-Rx, RATIO ALARM / SHUTDOWN POINTS Checked By _____



FEED DATA

- ◇ DESIGN POINT
- △ 3 SEC. ALARM POINT
- 10 SEC. SHUTDOWN
- IMMEDIATE SD.

RECYCLE DATA

- ⊗ DESIGN POINT
- ⊙ ESTIMATED POINT OF PREVIOUS EXPLOSION
- EXPLOSIVE RANGE

SHADED AREA REPRESENTS OPERATING RANGE
 WHERE IF FEED CONDITIONS EXIST FOR MORE
 THAN 3 SECONDS A TYPE WRITTEN ALARM RESULTS.
 (NO SHUTDOWN IS INITIATED!)

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 No. 91-1175

SL 012149



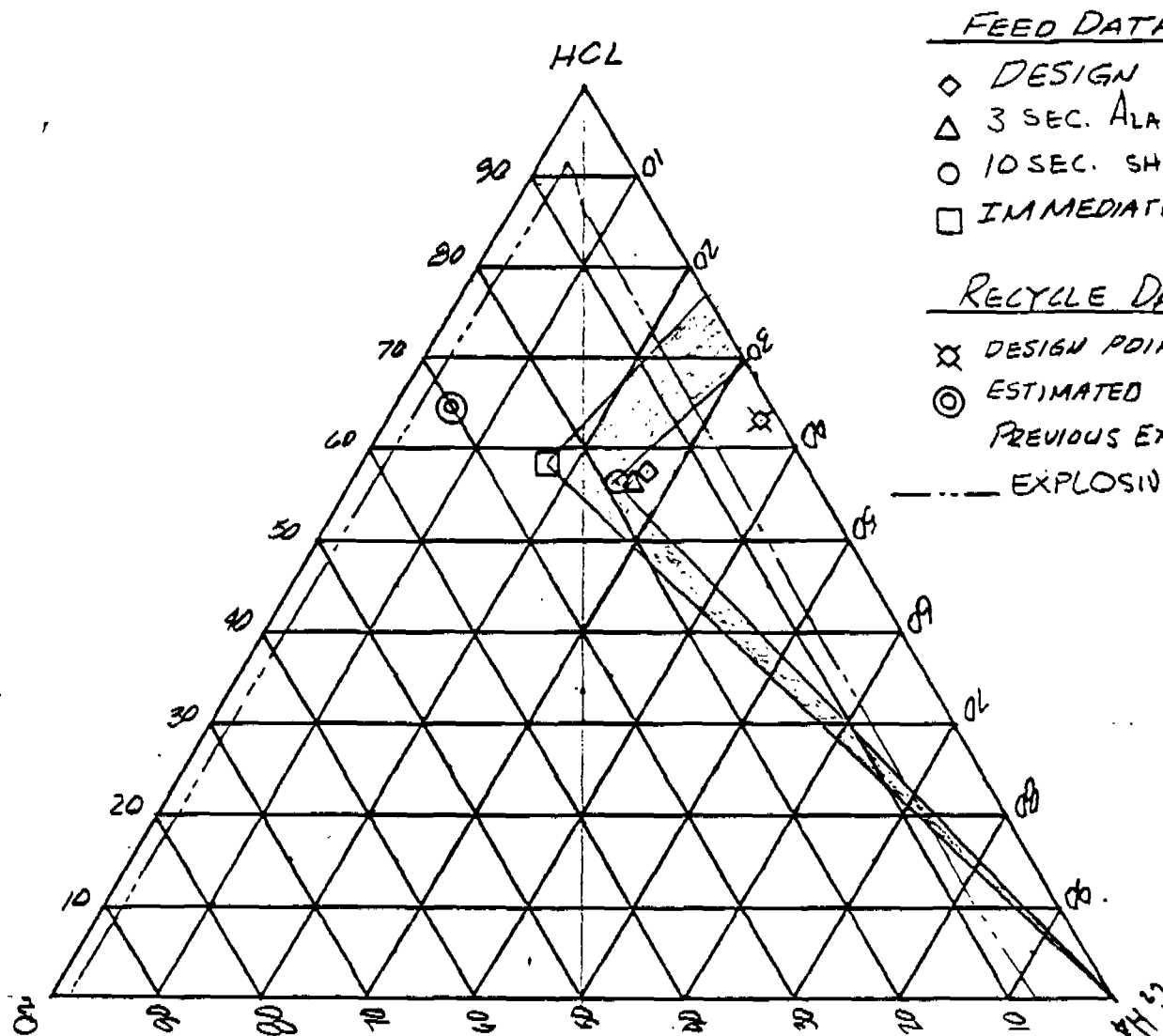
ENGINEERS & DESIGNERS

P. O. Box 3971 Beaumont, Texas 77704

713-332-4504

Page 18 of 3Job No P79.57

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 5/12/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject OHC-Rx, RATIO ALARM / SHUTDOWN POINTS Checked By _____

FEED DATA

- ◇ DESIGN POINT
- △ 3 SEC. ALARM POINT
- 10 SEC. SHUTDOWN
- IMMEDIATE SD.

RECYCLE DATA

- ⊗ DESIGN POINT
- ⊙ ESTIMATED POINT OF PREVIOUS EXPLOSION
- EXPLOSIVE RANGE

SHADED AREA REPRESENTS OPERATING RANGE
WHERE IF FEED CONDITIONS EXISTS FOR
MORE THAN 10 SECONDS SHUTDOWN IS IN-
ITIATED.

SL 012150



ENGINEERS & DESIGNERS

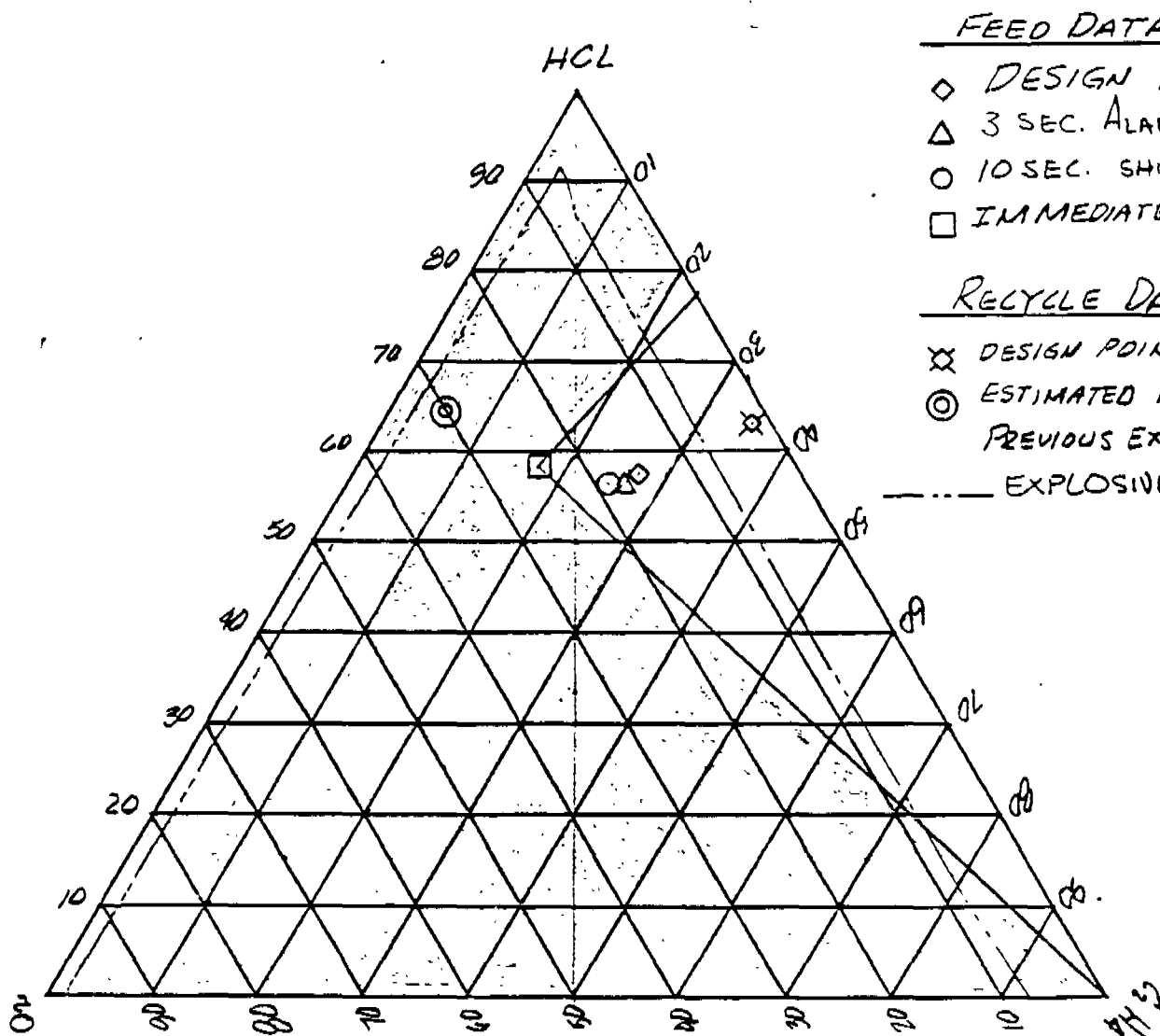
P. O. Box 3971 Beaumont, Texas 77704

713-332-4504

Page 10 of 3

Job No. P29,57

Client PPG - LAKE CHARLES, LA. Ref. _____ Date 5/12/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject OHC-Rx, RATIO ALARM / SHUTDOWN POINTS Checked By _____

FEED DATA

- ◇ DESIGN POINT
- △ 3 SEC. ALARM POINT
- 10 SEC. SHUTDOWN
- IMMEDIATE SD.

RECYCLE DATA

- ⊗ DESIGN POINT
- ⊙ ESTIMATED POINT OF PREVIOUS EXPLOSION
- EXPLOSIVE RANGE

SHADED AREA REPRESENTS OPERATING RANGE
WHERE IF CONDITIONS EXIST FOR AN
INSTANT SHUTDOWN IS INITIATED.

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ENGINEERS & DESIGNERS

P. O. Box 3971

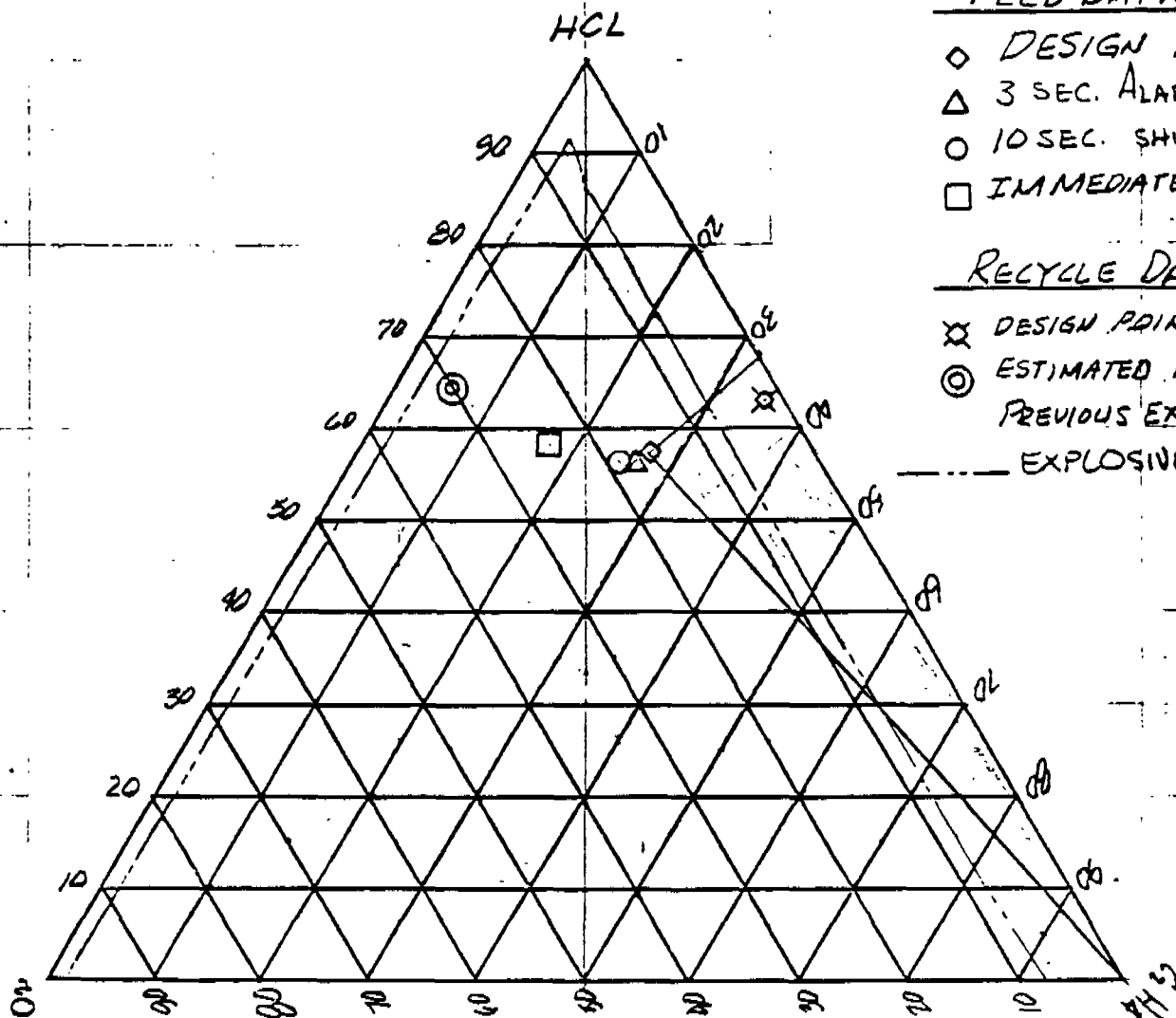
Beaumont, Texas 77704

713-832-4504

Page 10 of 3

Job No. P79.57

Client PPG-LAKE CHARLES, LA. Ref. 5/12/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject OHC-Rx, RATIO ALARM / SHUTDOWN POINTS Checked By _____

FEED DATA

- ◇ DESIGN POINT
- △ 3 SEC. ALARM POINT
- 10 SEC. SHUTDOWN
- IMMEDIATE SD.

RECYCLE DATA

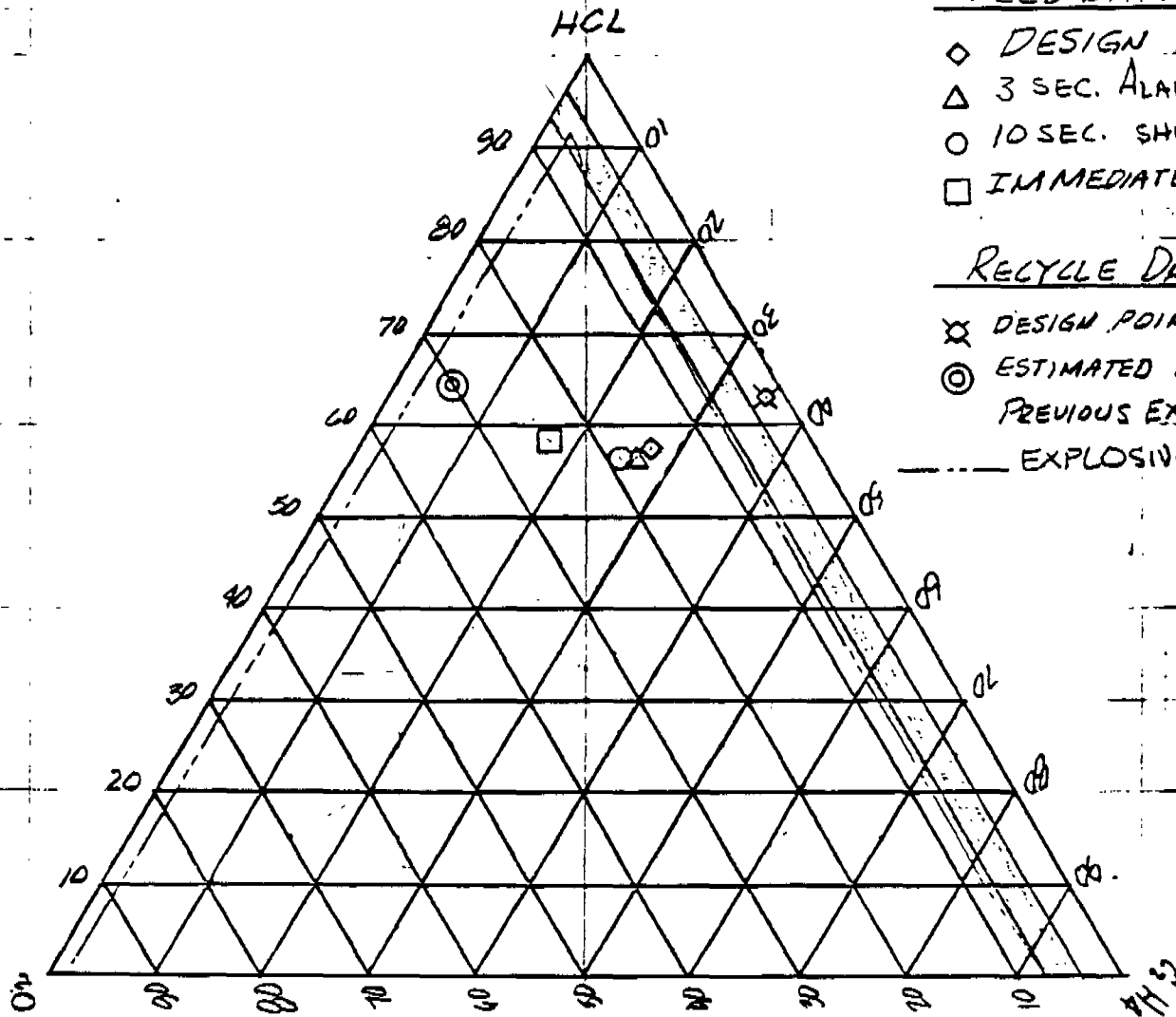
- ⊗ DESIGN POINT
- ⊙ ESTIMATED POINT OF PREVIOUS EXPLOSION
- EXPLOSIVE RANGE

SHADED AREA REPRESENTS SAFE OPERATING RANGE HOWEVER NOT ALL SHADED AREA IS AN ECONOMIC OPERATING RANGE.

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14th Judicial District Court
NO. 91-1145

Client PPG - LAKE CHARLES, LA. Ref. 5/12/80 Date 5/12/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject OHC-Rx, RATIO ALARM / SHUTDOWN POINTS Checked By 2 OF 3 OXYGEN ANALYZERS



FEED DATA

- ◇ DESIGN POINT
- △ 3 SEC. ALARM POINT
- 10 SEC. SHUTDOWN
- IMMEDIATE SD.

RECYCLE DATA

- ⊗ DESIGN POINT
- ⊙ ESTIMATED POINT OF PREVIOUS EXPLOSION
- EXPLOSIVE RANGE

SHADED AREA SHOWN IS OXYGEN LEVELS
 BETWEEN 4 AND 7% CONCENTRATIONS
 BETWEEN THESE TWO RANGES ARE ALARMED.
 CONCENTRATIONS ABOVE 7% INITIATE
 SHUTDOWN IMMEDIATELY.

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 No. 91-1145

SL 012153



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Beaumont, Texas 77704

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Page 15 of 3

Job No. 27957

Client PPG-LAKE CHARLES, LA.

Ref.

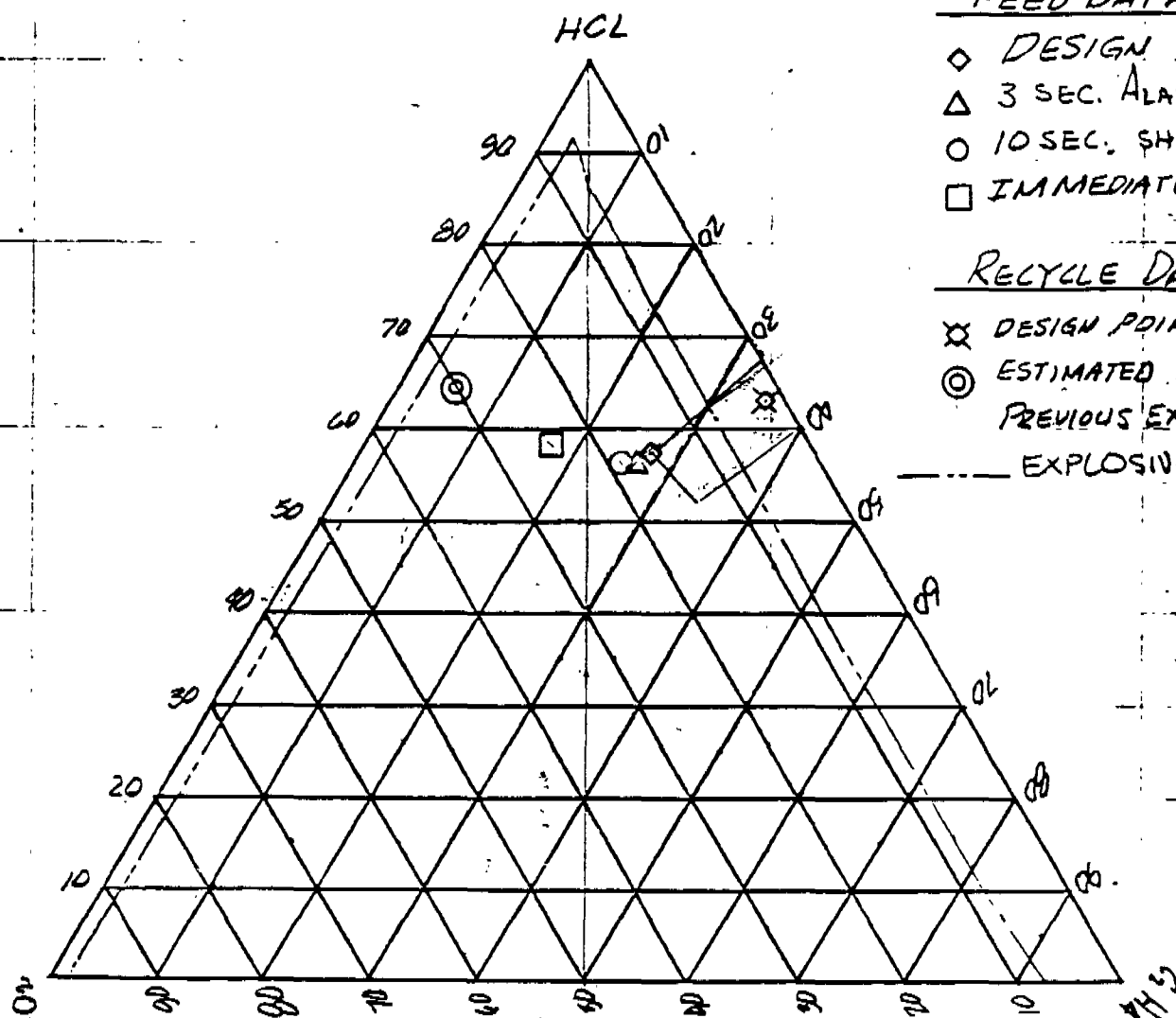
Date 5/12/80

Job VCM II - RELIABILITY STUDY, LEVEL III

By PA KELLEY

Subject OHC-Rx, RATIO ALARM / SHUTDOWN POINTS

Checked By



FEED DATA

- ◇ DESIGN POINT
- △ 3 SEC. ALARM POINT
- 10 SEC. SHUTDOWN
- IMMEDIATE SD.

RECYCLE DATA

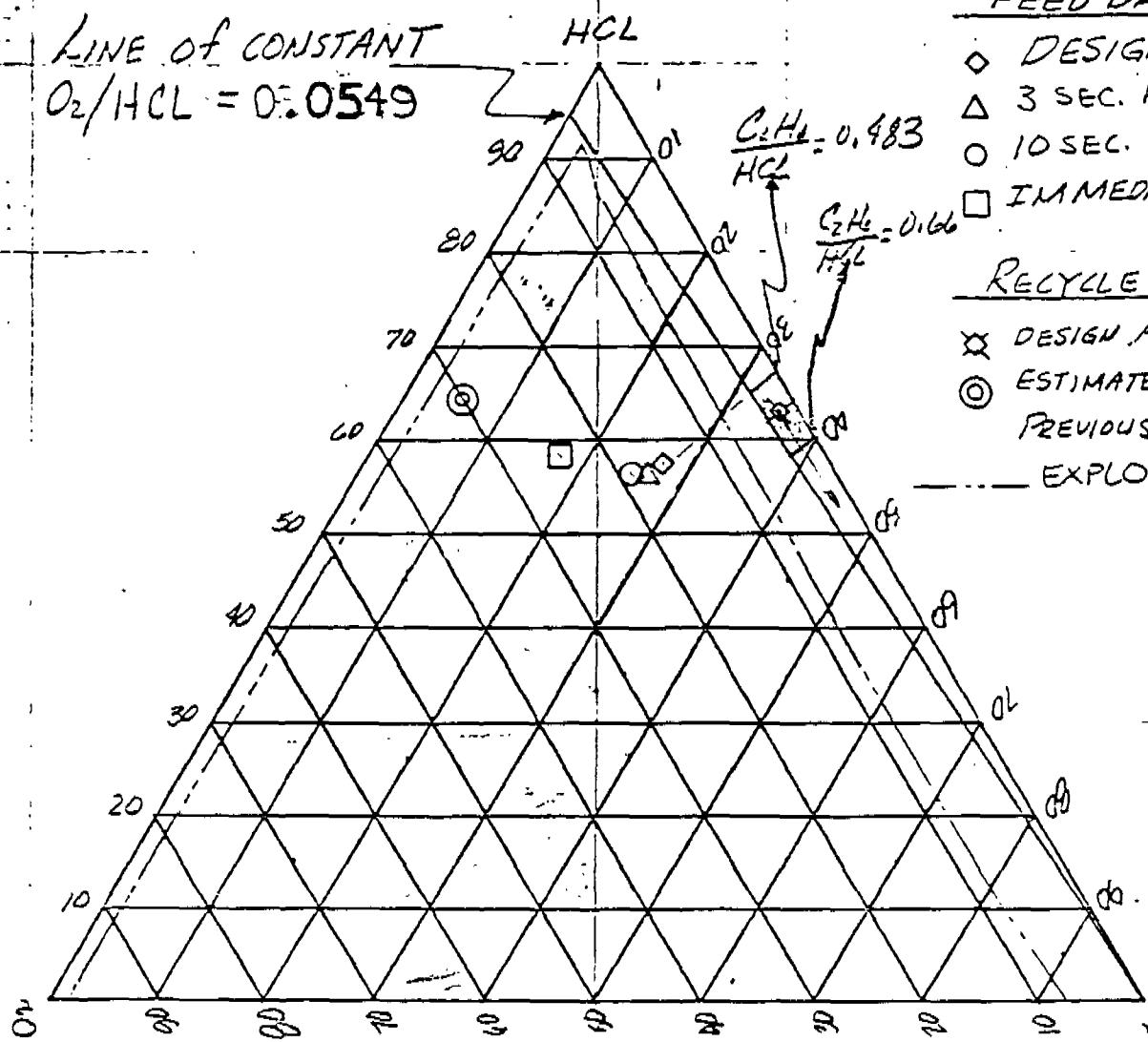
- ⊗ DESIGN POINT
- ⊙ ESTIMATED POINT OF PREVIOUS EXPLOSION
- EXPLOSIVE RANGE

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

SL 012154

Client PPG-LAKE CHARLES, LA. Ref. _____ Date 5/12/80
 Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
 Subject OHC-Rx, RATIO ALARM / SHUTDOWN POINTS Checked By _____

LINE OF CONSTANT
 $O_2/HCL = 0.0549$



FEED DATA

- ◇ DESIGN POINT
- △ 3 SEC. ALARM POINT
- 10 SEC. SHUTDOWN
- IMMEDIATE SD.

RECYCLE DATA

- ⊗ DESIGN POINT
- ⊙ ESTIMATED POINT OF PREVIOUS EXPLOSION
- EXPLOSIVE RANGE

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

Client PPG-LAKE CHARLES, LA. Ref. _____ Date 5/12/80
 Job VCM II - RELIABILITY STUDY, LEVEL II By PA KELLEY
 Subject OHC-Rx, RATIO ALARM / SHUT DOWN Checked By _____

	ETHYLENE & HCL		OXYGEN & HCL	
	RATIO	% C ₂ H ₄ / % HCL	RATIO	% O ₂ / % HCL
DESIGN	0.483	32.6/67.4	0.268	21.1/78.9
3SEC. ALARM	0.470	32.0/68.0	0.300	23.1/76.9
10SEC. SD.	0.440	30.6/69.4	0.325	24.5/75.5
IMM. SD.	0.300	23.1/76.9	0.410	29.1/70.9

DESIGN DATA:

$$\% \text{HCL} + 0.483 \% \text{HCL} = 100$$

% HCL = 67.4
 % C₂H₄ = 32.6

w/ 0.0% O₂

$$\% \text{HCL} + 0.268 \% \text{HCL} = 100$$

% HCL = 78.9
 % O₂ = 21.1

w/ 0.0% C₂H₄

DESIGN FEED

POINT LOCATION

3SEC. ALARM DATA:

$$\% \text{HCL} + 0.470 \% \text{HCL} = 100$$

% HCL = 68.0
 % C₂H₄ = 32.0

w/ 0.0% O₂

$$\% \text{HCL} + 0.3 \% \text{HCL} = 100$$

% HCL = 76.9
 % O₂ = 23.1

w/ 0.0% C₂H₄

3 SECOND ALARM
POINT LOCATION

SL 012156

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 of 14th Judicial District Court
 No. 91-1145



ENGINEERS & DESIGNERS

P O Box 3771

Beaumont, Texas 77704

713-832-4504

Page 3 Of 3Job No P79.57

Client PPG-LAKE CHARLES, LA. Ref. _____ Date 5/12/80
Job VCM II - RELIABILITY STUDY, LEVEL III By PA KELLEY
Subject OHC-RX, RATIO ALARM / SHUTDOWN POINTS Checked By _____

10 SEC. SHUT DOWN DATA:

$$\% \text{HCL} + 0.44 \% \text{HCL} = 100$$

$$\% \text{HCL} = 69.4$$

$$\% \text{C}_2\text{H}_4 = 30.6$$

w/ 0.0% O_2

$$\% \text{HCL} + 0.325 \% \text{HCL} = 100$$

$$\% \text{HCL} = 75.5$$

$$\% \text{O}_2 = 24.5$$

w/ 0.0% C_2H_4 10 SEC. ALARM
POINT LOCATION

IMMEDIATE SHUT DOWN DATA:

$$\% \text{HCL} + 0.30 \% \text{HCL} = 100$$

$$\% \text{HCL} = 76.9$$

$$\% \text{C}_2\text{H}_4 = 23.1$$

w/ 0.0% O_2

$$\% \text{HCL} + 0.41 \% \text{HCL} = 100$$

$$\% \text{HCL} = 70.9$$

$$\% \text{O}_2 = 29.1$$

w/ 0.0% C_2H_4 IMMEDIATE SHUTDOWN
POINT LOCATION

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No. 91-1145

SL 012157