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November 17, 1987

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REACTIVE CHEMICALS COMMITTEE REVIEW - OCTOBER 29, 1987

PROJECT: Ethylene Recovery Pilot Plant at Glycol II - Capital Project

PROJECT REPS: Hal Martin, John Pendergast, Steve Mims, Buck Bailey, Wayne Turner

COMMITTEE PRESENT: Pennington, Simpson (Nevill), Bullman, Henley, Christensen, Mitchell, Diamond (Cochran)

GUESTS: Doug Merrick, Fred Lochary, Dave Courter (LAS&TL)

CONSIDERATIONS:

1. Determine the fate of acetylene if introduced in the feed gas; will it concentrate in the Norpar 107 (Aspen)?
2. Determine the effect of varying ethylene concentration in the feed on the flammability of the stripper overhead.
3. Install an oxygen analyzer on the compressor suction to shutdown the system to prevent a flammable mixture in the second stage discharge.
4. Delay nitrogen EBV on absorber from opening until T-70 pressure is equal to or less than 120 psig.

5. Install redundant pressure switch on T-80 stripper overhead for shutdown upon sensing a vacuum.

6. Install redundant level switch on D-1002 to prevent liquid carryover into C-1002 compressor.

7. Install high pressure switch on C-1002 to shutdown in the event of overpressure condition on the discharge.

Please respond in writing to the Committee Chairman within one month as to action taken or planned in regard to these considerations.

J. Y. Pennington, Chairman
REACTIVE CHEMICALS COMMITTEE

rcb

ETHYLENE RECOVERY PILOT PLANT

PROJECT AT GLYCOL II

INTRODUCTION

Ethylene recovery is a process for recovering a low molecular weight olefin from an inert gas stream via absorption with a higher molecular weight organic compound. The application of the invention is to recover the ethylene from the purge gas of an air based ethylene oxide plant to increase the feed ethylene concentration to the ethylene oxide reactors.

BACKGROUND:

An air based ethylene oxide (EO) plant requires the use of air as a source of oxygen for the direct oxidation of ethylen to EO. Due to the use of air, nitrogen is carried with the oxygen to the process. The nitrogen is inert to the reaction and flows through the system. In order to maintain the reactor pressure at a constant level the nitrogen must be purged from the reactor system at a rate equivalent to the inlet nitrogen flow. The purged nitrogen leaves in a mixture of gas which is the effluent from the primary reactors. A set of "purge reactors", usually three to four in series, are used to react the ethylene in the purge stream to EO. Supplemental air is added to these purge reactors to make up the depleted oxygen from the previous reactor. The remaining ethylene in the effluent from the last purge reactor must be burned before it can be released to the atmosphere because of environmental concerns. The hot gas from the heater is used to drive the air compressor through an expander and then it is released to the atmosphere. The "tail gas" (effluent from last purge reactor) ethylene concentration must be kept below a maximum limit due to the heat transfer limitations of the heater equipment and the economics of using a primary feed stock as fuel. The maximum concentration of ethylene in the tail gas limits the concentration of ethylene in the primary reactor loop.

The problem resides in the fact that the efficiency of the overall process to convert ethylene to EO is diminished by the limit on the ethylene concentration in the primary loop. The fficiency of the catalytic direct oxidation of ethylene to EO is increased as the ethylene concentration on the catalyst is increased. The benifits of increased ethylene begin to platue at 15 mole % in the gas. Typical air plants run between 7 to 8 mole percent ethylene in the primary loop. The concentration of ethylene decreases in each purge reactor which also reduces the efficiency of the plant. However, the low concentrations in the purge reactors,(5.0 mole % in R-2, 3.0 % in R-3, and 1.5 % in R-4) is a direct result of the limit of ethylene in the primary reactor loop.

Th solution to th problem is to r cov r th ethyl n in the "tail gas" and allow the concentration of ethylene to increas from 7-8 % to 12-15 % in the primary loop. The ethylene recovery process would increase the limit on the tail gas ethylene and allow the front end ethylene concentration to increase. As the ethylene concentration is increased in the primary loop, the reactor efficiency would increase. The majority of the benifit would reside in the increased efficiency of the purge reactors which lower the overall plant yield substantially. The ethylene is recovered by counter-current absorption with a organic solvent in a packed column. The dissolved gasses are stripped in another packed column by heating the solution and injecting live steam to liberate a maximum amount of ethylene from the mixture. The gas str am from the stripper is sent to another smaller absorber/stripper operation to remove and recover CO2 via an amine solvent system. CO2 is not desirable to recycle back to the reactors since it inhibits th direct oxidation of ethylene to EO and reduces the catalyst fficiency. The resulting nitrogen/ethylene mixture is then recompressed and recycled to the primary loop. The nitrogen flow back to the system is compensated for by the addition of pure oxygen as a supplyment to the compressed air that is fed to the process. Supplimental oxygen is typically added to existing air plants to reduce the load on the air compressor and allow the machine to run more efficiently.

The ethylene recovery pilot plant will only deal with the absorption and stripping of ethylene via organic solvent since CO2 absorption and stripping is known technology.

THE ADVANTAGES:

The advantages over an existing air plant is the increased overall plant efficiency of converting ethylene to EO due to the increase in the ethylene concentration in the primary loop as well as the substage, or purge reactors. Also, the invention increases the yearly production of EO by 4-6 %. A typical air plant yield of EO is 3-3.5 % below the yield of the primary reactors. With the ethylene recovery addition, the plant yield is increased to 1-0.5 % less than the primary reactor yields. Another benifit of the invention is the recovery of a saleable CO2 stream from the amine absorber/stripper system. This stream could provide an additional source of revenue to the plant operation.

ETHYLENE RECOVERY PILOT PLANT PROCESS DESCRIPTION

OBJECTIVES

The objectives of the ethylene recovery pilot plant are enum rat d below.

1. Demonstrate the feasibility of ethylene recovery via physical absorption.

2. Determine the process flexibility and correlation to th ASPEN simulation model.

3. Determine the effect of trace impurities on the solvent life.

4. Determine the effect of recovered ethylene on catalyst performance.

The plans are to start-up the pilot plant by the end of Novemb r 1987 and run through the third quarter of 1988. The capital authorization for the plant installation will be submitted in th third quarter of 1988 with plans for installation in the third quarter of 1989.

GENERAL DESCRPTION:

The ethylene recovery pilot plant will use NORPAR 10 as the solv nt to absorb ethylene. NORPAR 10 is a product made by Exxon and is a mixture of normal parrafins ranging from C9 to C11. NORPAR 10 has b en determined to be the best solvent for the ethylene absorption process based on its affinity for ethylene and its relatively low vapor pressure and low reactivity. The product information bulletin and MSDS sheets, as well as the ARC data for NORPAR 10 and the feed gas are attached.

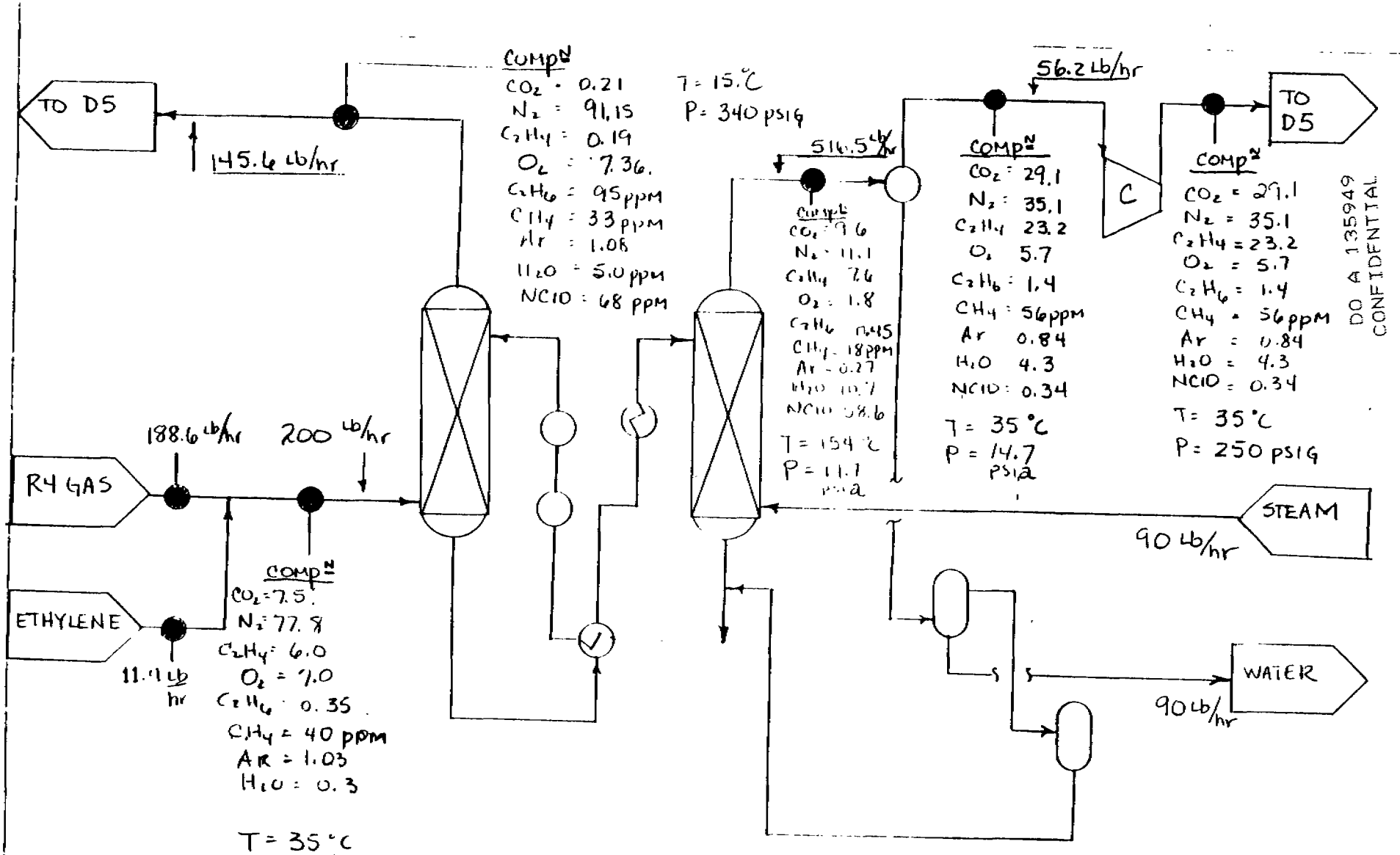
The process is contercurrent gas absorption in a packed column coupled with countercurrent gas stripping, also in a packed column, utilizing 30 psig steam as the motive fluid. A phase separation unit will also be run in the process due to the use of steam as a stripping gas. The water and NORPAR 10 which condenses from the stripper must be separated so that the water can be removed from the system. The stripper overhead stream, which is rich in ethylene, carbon dioxide and nitrogen, is compressed and returned to Glycol II's heater 2 were the organics are burned prior to entering the purg gas expander. The stripper overheads will also be used in experiments to etermine the effect of recovered ethylene and trace amounts of solvent on the ethylene oxide catalyst. The absorber overhead will b burned in Glycol II's heater 2 in the same manner as the stripp r ffluent. The water from the phase separator is sent through a carbon filter prior to dicharging to the holding pond.

THE RAW MATERIALS

The feeds for the ethylene recovery pilot plant are R4 feed gas, ethylene, 30 psig steam and NORPAR 10. R4 feed gas is the gas mixtur which is fed to the last purge reactor. The typical analysis of the R4 gas mixture is (mole %):

C2H4	: 2.0%
O2	: 7.5%
CO2	: 8.0%
C2H6	: 0.25%
TOTAL CHLORIDES	: 0.5 PPM
BALANCE	: NITROGEN

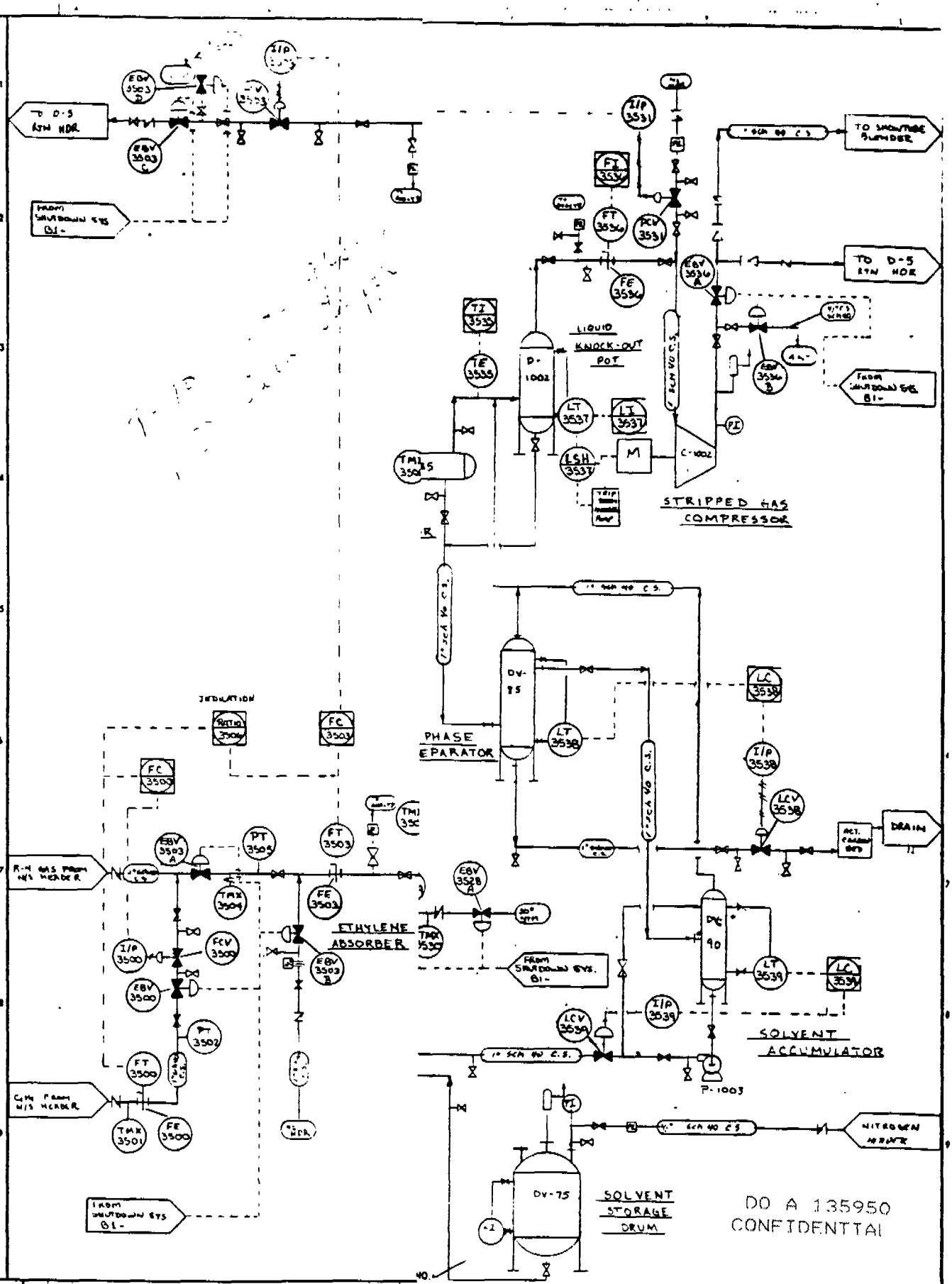
Ethylene is added to the R4 gas to increase the ethylene concentration to levels that are anticipated once ethylene recovery is operating in Glycol II. The concentration range of ethylene that will be used in the feed gas to the absorber is 6 to 10 percent (molar).
Steam is used as an inert gas to strip the dissolved ethylene, carbon dioxide and nitrogen from the rich solvent. The steam pressure us d is 30 psig, or low pressure steam. See the attached simplified flow sh et for compositions, temperatures, pressures, and flows.



ETHYLENE RECOVERY PILOT PLANT DIAGRAM

ALL COMPOSITIONS IN MOLE PERCENT

HBM: 10/87



INSTRUMENT NUMBERS CHANGED TO GLYCOL II NOMENCLATURE - FIRST # 3500, LAST # 3539

FINAL DWG. ISSUED WITH B1-76180

DOW CHEMICAL U.S.A.
LOUISIANA DIVISION

GLYCOL II BLOCK 53
ETHYLENE RECOVERY PILOT PLANT
PIPING AND INSTRUMENTATION DIAGRAM

JOB NUMBER 76180 | SCALE | B1-081-655-001

PRINTED 4/3/87

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ETHYLENE RECOVERY PILOT PLANT

ABSORBER FEED GAS FLAMMABILITY CASE 4 - 6 - INLET GAS

COMPOSITION, MOLE %

CO_2	= 8.0	P =	320 psig
N_2	= 76.92	T =	35 C
C_2H_4	= 6.0		
O_2	= 7.5	FLOW =	200 lb/hr
C_2H_6	= 0.25		
C_3	= 40 ppm		
Ar	= 1.03		
H_2O	= 0.3		

PROBLEM: CONCERN THAT MIXTURE IS FLAMMABLE WITH 6.0 % C_2H_4 AND 7.5% O_2.

SOLUTION: ACCORDING TO J.B. POWERS' EMPIRICLE MATHEMATICAL MODEL FOR THE MAXIMUM ALLOWABLE OXYGEN CONCENTRATION, (MAOC) ETHYLENE-OXYGEN-NITROGEN SYSTEMS THE MAOC IS 9.2 %. THEREFORE, THE INLET GAS TO THE ABSORBER IS NOT IN THE FLAMMABLE REGION. AS A MATTER OF FACT, THE ETHYLENE CONCENTRATION CAN BE AS LOW AS 5.0 % AT THE ABSORBER TEMPERATURE AND PRESSURE BEFORE THE MIXTURE BECOMES FLAMMABLE.

THE ETHYLENE FLOW REQUIRED TO ACHIEVE 5.0% IN THE FEED GAS IS 95 lb/hr. THE MAXIMUM FLOW THROUGH THE CONTROL VALVE AT THE TEMPERATURE AND PRESSURE OF THE ETHYLENE HEADER IS 50 lb/hr. HENCE, A FLAMMABLE MIXTURE CANNOT BE ATTAINED.

ALSO, ARC 389 SHOWS NO DETECTABLE THERMAL ACTIVITY BETWEEN NORPAR 10 AND A GAS MIXTURE SIMULATING THE ABSORBER FEED GAS. (SEE ATTACHED REPORT FROM THE LA. REACTIVE CHEMICALS LAB)

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STRIPPER OVERHEAD FLAMMABILITY CASE : 9.0% INLET ETHYLENE

COMPOSITION ; MOLE %

CO_2	= 8.6
N_2	= 8.4
C_2H_4	= 9.7
O_2	= 1.5
C_2H_6	= 0.27
CH_4	= 14 ppm
Ar	= 0.21
H_2O	= 65.76
NC10	= 5.5

P = 16.7 psig
T = 90 °C

FLOW = 183 #/hr

PROBLEM : CONCERN THAT ETHYLENE AND NORPAR 10 VAPOR MIXED WITH 1.5% O_2 IS FLAMMABLE.

SOLUTION : AGAIN REFERRING TO THE "POWERS' FORMUALA" FOR MAOC THE EQUATION PREDICTS THAT THE MAOC, AT THE ABOVE TEMPERATURE AND PRESSURE, IS 7.97%, THEREFORE THE MIXTURE IS NOT COMBUSTIBLE FROM THE PRESENCE OF ETHYLENE NOW LETS ADDRESS THE NORPAR 10 VAPOR (NC10), ACCORDING TO THE M.S.D.S FROM EXXON ON NORPAR 10, THE FLAMMABLE LIMITS IN AIR ARE 0.6 TO 7.0 VOLUME PERCENT. HOWEVER, SINCE THE O_2 CONCENTRATION IS ONLY ONE-FOURTEENTH OF THE O_2 CONCENTRATION IN AIR IT STANDS TO REASON THAT THE FLAMMABLE LIMITS OF THE NORPAR CHANGES. IN FACT, THE MAXIMUM SAFE O_2 CONCENTRATION FOR BUTANE AND HIGHER HYDROCARBONS IS 12.1% TO 14.5%, ACCORDING TO B. LEWIS AND G. VON ELBE, "COMBUSTION, FLAMES, AND EXPLOSIONS OF GASES", pg 698, APPENDIX B.

ALSO, THE ADIABATIC PRESSURE RISE WAS CALCULATED BASED ON A STATIC STRIPPER FILLED WITH A GAS WITH THE ABOVE COMPOSITION AT A PRESSURE OF 50 PSIG AND 90 °C. THE ASSUMPTION WAS TO TAKE THE ETHYLENE AND REACT WITH THE LIMITING O_2. THIS WAS DONE BECAUSE C_2H_4 GAVE THE LARGEST ENERGY RELEASE. AS O_2 REACTS WITH ETHYLENE TO FORM CO_2 AND WATER, THE TEMPERATURE INCREASED TO 233 °C AND THE PRESSURE ROSE TO 70 PSIG. THIS IS WELL WITHIN THE RELIEF VALVE SETTING OF 100 PSIG ON T-80.

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CONDENSOR OVERHEAD FLAMMABILITY: w/ 9% INLET ETHYLENE

COMPOSITION, MOLE %

CO_2	= 28.6	P = 14.7	PSIA
N_2	= 27.9	T = 90	°C
C_2H_4	= 32.		
O_2	= 5.09	FLOW = 62	lb/hr
C_2H_6	= 0.9		
CH_4	= 47	PPM	
Ar	= 0.70		
H_2O	= 4.3		
NC10	= 0.35		

PROBLEM: CONCERN THAT THE GAS MIXTURE LEAVING THE CONDENSOR IS FLAMMABLE WITH 32% C_2H_4 AND 5.09 % O_2 AT THE TEMPERATURE AND PRESSURE OF THE SYSTEM.

SOLUTION: REFERENCING TO POWERS' FORMULA ONCE AGAIN, THE REPORTED MOC FOR A $N_2-O_2-C_2H_4$ MIXTURE AT THIS TEMPERATURE AND PRESSURE IS 3. %. THEREFORE, THE MIXTURE IS NOT FLAMMABLE.

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COMPRESSOR DISCHARGE FLAMMABILITY : w/ 9% INLET ETHYLEN

COMPOSITION MOLE %

CO_2	=	28.6	P = 350 psig
N_2	=	27.9	T = 40 °C
C_2H_4	=	32.1	
O_2	=	5.09	FLOW = 62 lb/hr
C_2H_6	=	0.9	
CH_4	=	47 ppm	
Ar	=	0.7	
H_2O	=	4.3	
NC10	=	0.35	

PROBLEM : CONCERN THAT THE COMPRESSOR DISCHARGE GAS MIXTURE IS FLAMMABLE WITH 32% C_2H_4 AND 5.09% O_2 AT THE TEMPERATURE AND PRESSURE OF THE SYSTEM.

SOLUTION : ACCORDING TO THE POWERS' FORMULA THE MAOC FOR THE ABOVE GAS MIXTURE IS 8.1% AT 40°C AND 350 PSIG. THEREFORE THE GAS MIXTURE IS NOT IN THE FLAMMABLE REGION.

5.0 EMPIRICAL MATHEMATICAL MODEL FOR THE MAXIMUM ALLOWABLE OXYGEN CONCENTRATION IN ETHYLENE-OXYGEN-NITROGEN SYSTEMS

Based on data from recent literature (8, 10, 15), an empirical mathematical model describing the maximum allowable oxygen concentration (MAOC) as a function of ethylene concentration, temperature, and pressure has been developed. The primary data used came from the work of Grosse-Wortmann (8). These experiments were carried out in such a manner that the MAOC could be derived for various ethylene concentrations at a constant temperature (200°C) for several pressures (1-26 atm) and at a constant pressure (26 atm) for several temperatures (100-280°C).

The model was developed by fitting the MAOC as a function of one variable while holding the other two constant. This allowed the functional form which best described the variations due to that variable to be determined. In Figures 5.0-1 and 5.0-2 the MAOC has been plotted as a function of temperature and of pressure, respectively, for various ethylene concentrations. The MAOC seems to vary almost linearly with temperature. The MAOC variation with pressure can be described by the sum of a P^3 term and a 1/P term. Using the terms which seemed to best describe the two portions of the data as a starting point, a stepwise linear least squares computer program was used to derive an equation which described the MAOC as a function temperature, pressure, and ethylene concentration. The final equation is:

FIGURE 5.0-1

Maximum Allowable Oxyg n Concentration as a Function of Temperatur at 26 Atmosph res for Various Ethylene Concentrations

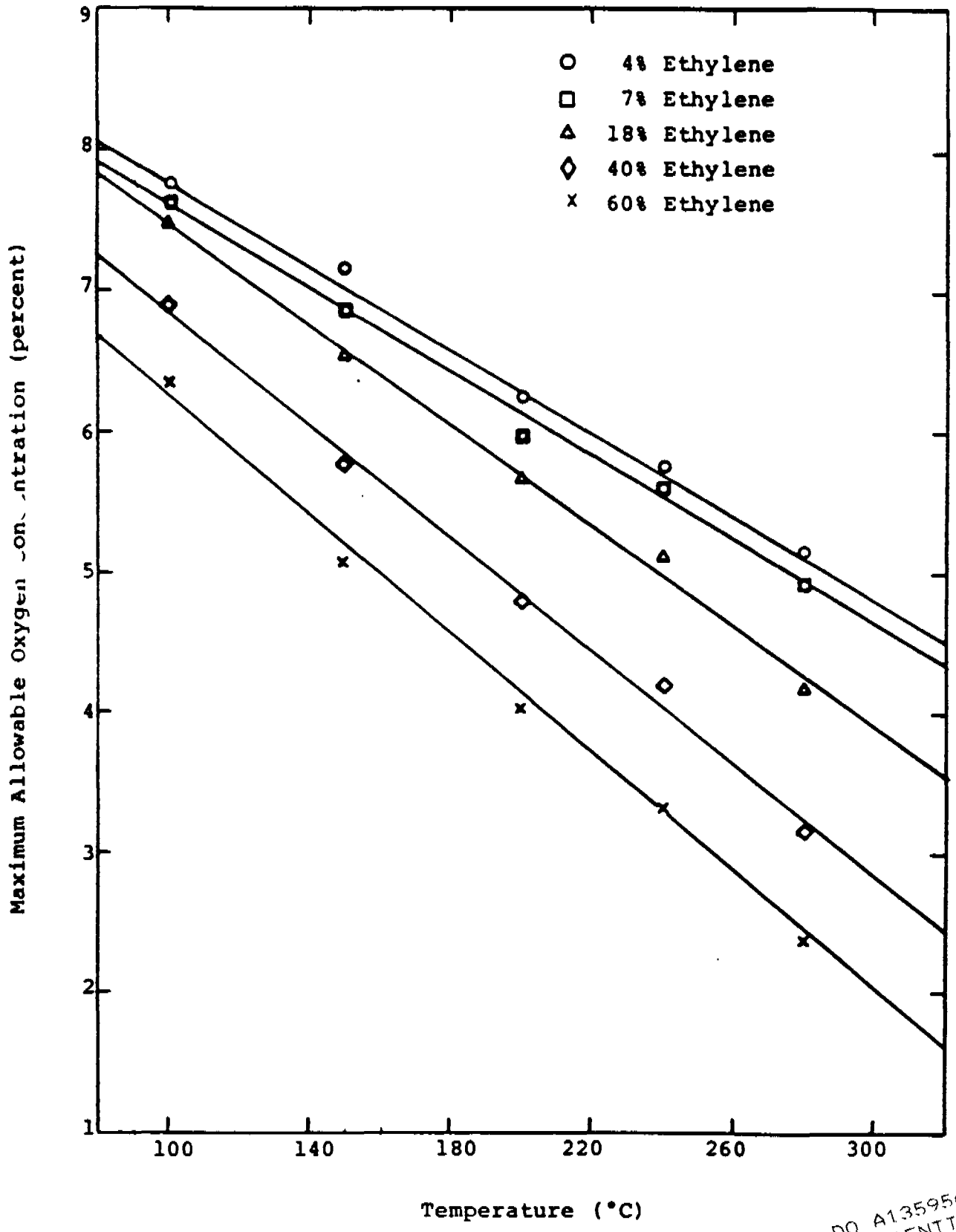
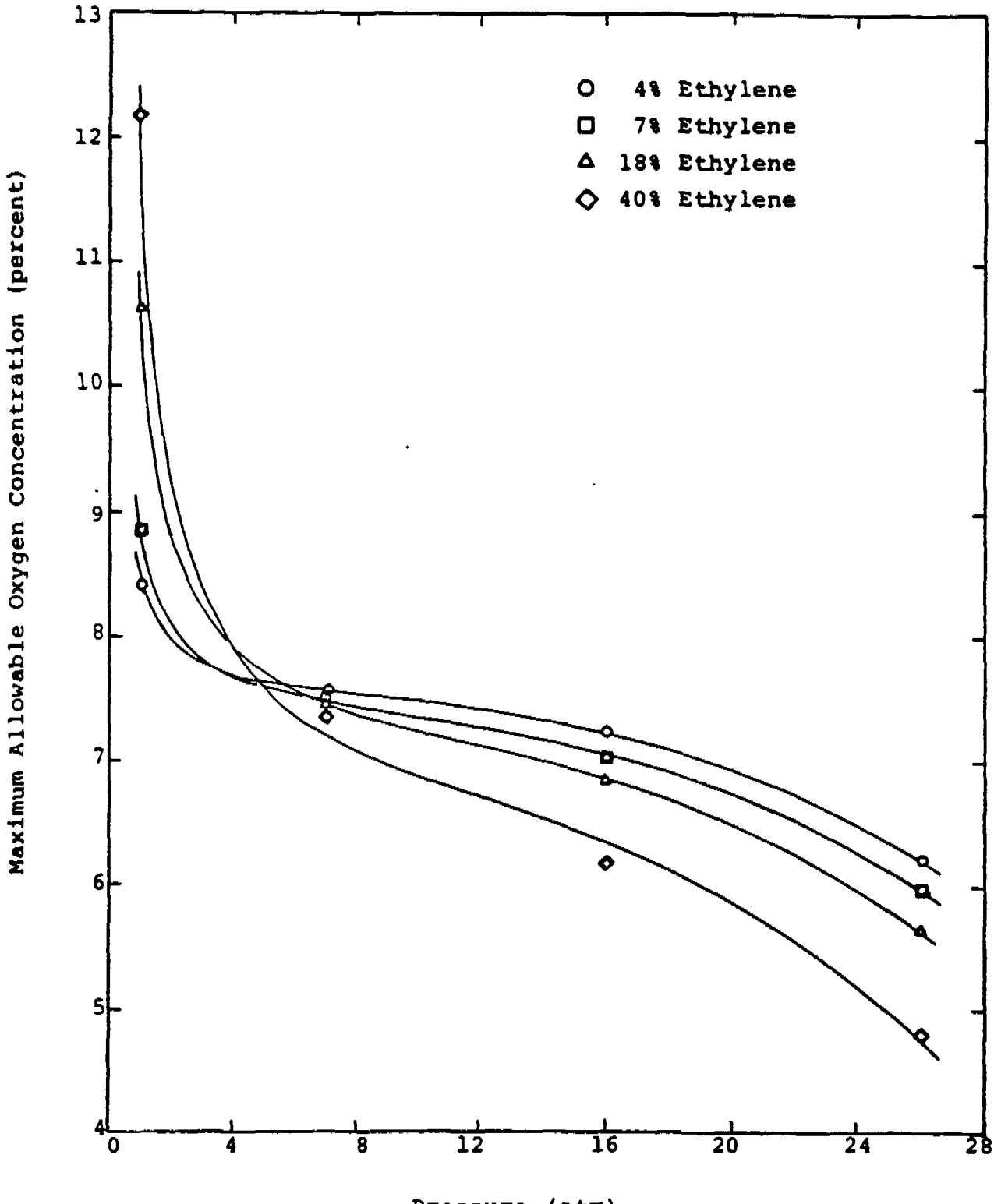


FIGURE 5.0-2

Maximum Allowable Oxygen Conc ntration as a Function of Pressure at 200°C for Various Ethylene Conc ntrations



$$MAOC = -0.589 + .0189T + .534P - 0.00128PT - 6.22\times10^{-5}TE$$
$$-1.64\times10^{-9}P^3TE + 0.534E/P - 8.77\times10^{-4}\frac{TE}{P}$$

where

MAOC = maximum allowable oxygen concentration

T = temperature in degrees Kelvin

P = total pressure in atmospheres

E = ethylene concentration in mole percent.

The calculated MAOC surface as a function of temperature and pressure is shown in Figures 5.0-3 and 5.0-4 for ethylene concentrations of 4% and 18%, respectively.

This mathematical model for the MAOC is admittedly limited in its range of applicability. It was based on data for ethylene concentrations between 4 and 60 percent. The pressure dependency of the MAOC between 1 and 26 atmospheres was determined only at one temperature (200°C). The temperature dependency between 100 and 280°C was derived at only one pressure (26 atm). The lack of data to define the variation of the MAOC as a function temperature at other pressures and the variation as a function of pressure at other temperatures makes the prediction of the MAOC less reliable for conditions which do not approximate the experimental conditions used to build the model. However, some limited data were included in the final model determination at other temperatures and pressures to partially overcome this deficiency. Even then, care must still be used when evaluating

FIGURE 5.0-3

Calculated Maximum Allowable Oxygen Concentration as a Function of Temperature and Pressure for Mixtures Containing 4% Ethylene with Nitrogen as the Ballast Gas

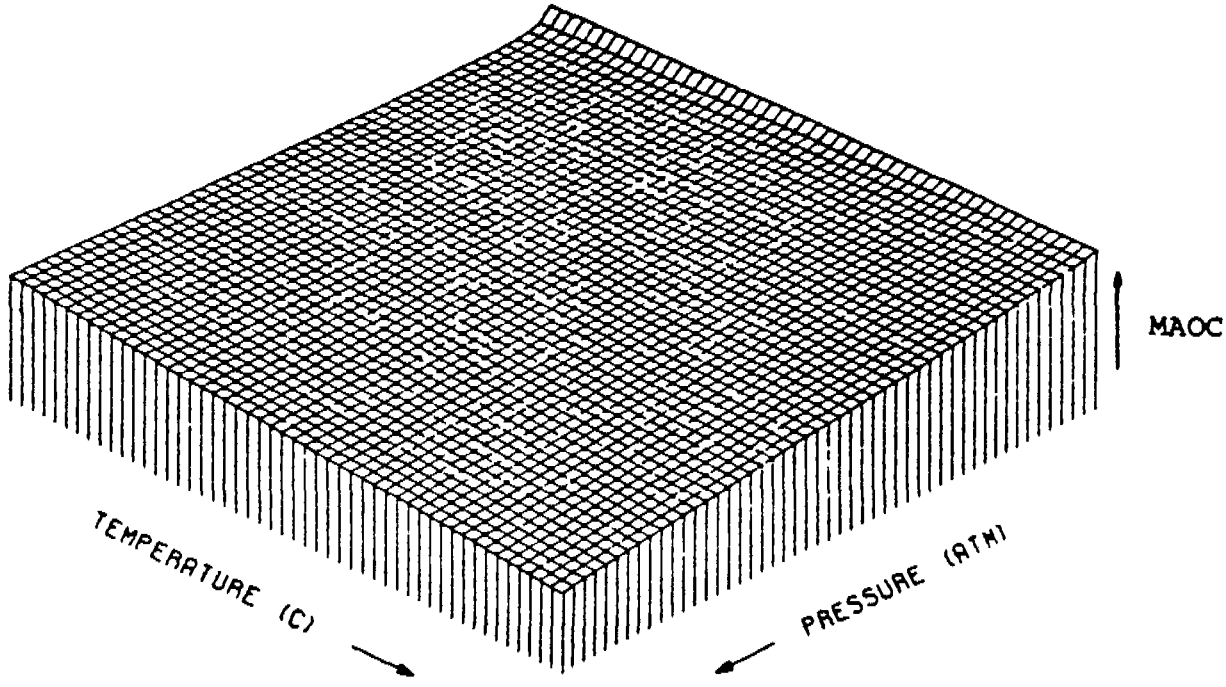
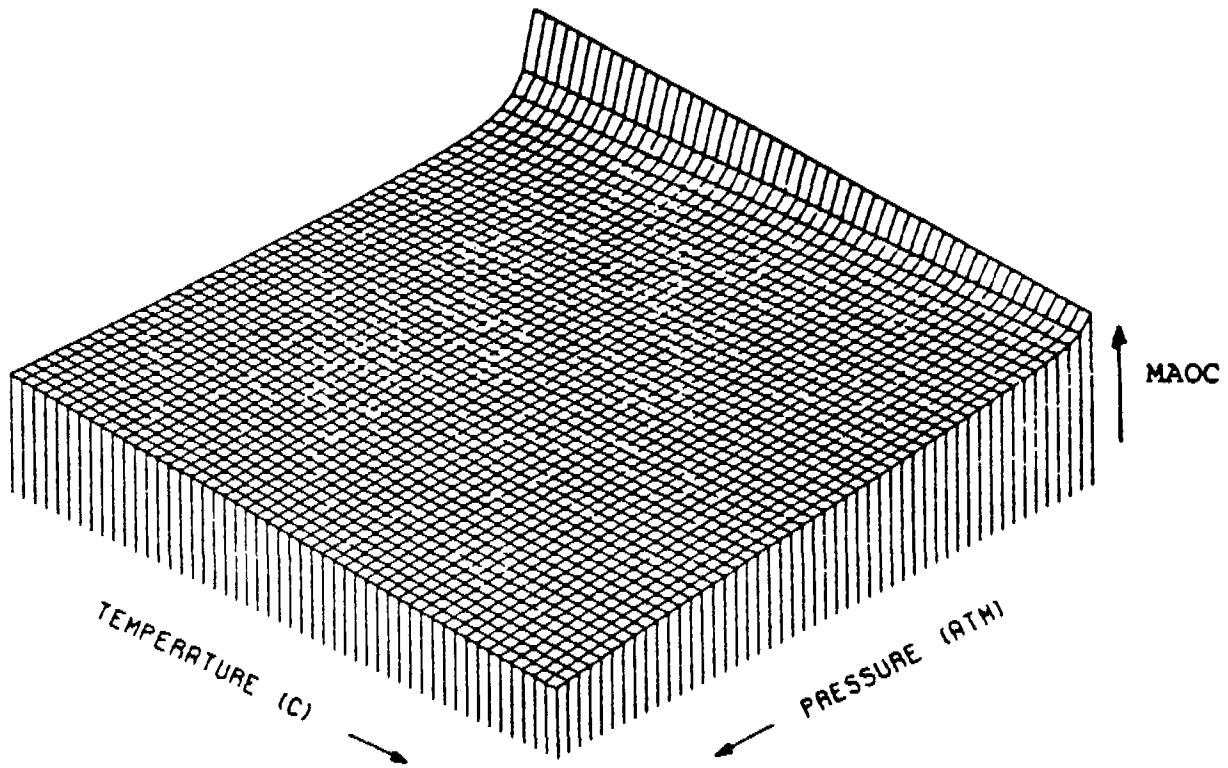


FIGURE 5.0-4

Calculated Maximum Allowable Oxygen Concentration as a Function of Temperature and Pressure for Mixtures Containing 18% Ethylene with Nitrogen as the Ballast Gas



the MAOC using this model for other temperatures and pressures that do not approximate the experimental data used to develop the model.

For comparison purposes the MAOC calculated using the model and some values measured at this laboratory have been tabulated in Table 5.0-1. The greatest deviation is at low temperatures or low pressures, but in general there is good agreement between the measured values and the predicted values.

The error limit for the experimental data was estimated from the errors in the analytical techniques and estimat d errors in experimental technique. The error limits for the calculated data is the 95% confidence interval calculat d by the technique of Draper and Smith (28).

TABLE 5.0-1

Experimental and Calculated Maximum Allowable Oxygen Concentrations for Various Conditions

Ethylene %	Temp °C	Press atm	Measured MAOC	Predicted MAOC and 95% C.I.	P-M Diff	Ref.
3.5	250	6.8	7.6 ±0.3	8.26 ± 0.48	0.66	25
3.5	250	11.57	7.1 ±0.3	7.58 ± 0.37	0.47	25
3.5	250	14.97	6.9 ±0.3	7.10 ± 0.29	0.20	25
3.5	250	18.37	6.8 ±0.3	6.62 ± 0.22	-0.18	25
3.5	250	21.77	6.55±0.3	6.13 ± 0.16	-0.42	25
4.0	220	18.71	7.0 ±0.3	6.72 ± 0.12	-0.28	6
5.0	220	18.71	6.9 ±0.3	6.69 ± 0.12	-0.21	6
3.5	265	17.01	6.78±0.3	6.76 ± 0.32	-0.02	7
3.5	250	15.3	6.89±0.3	7.05 ± 0.28	0.16	7
3.5	280	15.3	6.50±0.3	7.02 ± 0.44	0.52	7
3.5	250	18.71	7.05±0.3	6.57 ± 0.21	-0.48	7
3.5	280	18.71	6.70±0.3	6.40 ± 0.33	-0.30	7
3.5	150	18.71	7.84±0.3	7.13 ± 0.22	-0.71	7
3.5	220	18.71	7.17±0.3	6.74 ± 0.12	-0.43	7
18.0	225	20.4	6.2 ±0.3	6.04 ± 0.11	-0.16	5
18.0	235	23.47	5.0 ±0.3	5.50 ± 0.10	0.50	This Work

6.0 SUMMARY AND CONCLUSIONS

As was stated before, it has been shown that absolute flammability limits do not exist. Therefore, it is absolutely necessary to recognize and appreciate the variables which can influence measured limits. Further, these variables must be controlled so as to minimize their effect on the measured flammability limits. The experimental variables which have been identified as being important in the study of ethylene flammability are:

1. Bomb shape and size
2. Direction of flame propagation
3. Ignition source size and type
4. Method of determining composition of mixtures
5. Method for minimizing decomposition of mixtures
6. Criteria for defining flame propagation.

In this study the decomposition rate of ethylene-oxygen-nitrogen-carbon dioxide mixtures at 250°C is sufficiently rapid to require modification of the gas handling techniques. At 300°C the rate of decomposition is very rapid. It can be concluded that hot spots greater than 300°C could be sources of ignition.

The maximum allowable oxygen concentration has been measured under the following conditions:

Temperature	: 235°C
Pressure	: 345 PSIA
Ethylene	: 18.0 percent
Carbon Dioxide	: 4.5 percent
Nitrogen	: Balance minus MAOC

Under these conditions the maximum allowable oxygen concentration was found to be 5.0±.3 percent.

A mathematical model for the MAOC has been developed using data from the general literature. This model provides a technique for calculating the MAOC as a function of ethylene concentration, temperature and pressure, within the limitations described in Section 5. The model is in good agreement with data developed within this laboratory. The calculated MAOC for the "air process" ethylene oxide plants located at Sarnia, Canada, at Plaquemine, Louisiana, and at Freeport, Texas, show that these plants are operating outside of the flammability envelope. However, the "oxygen process" ethylene oxide plant located at Terneuzen, The Netherlands, is operating within the flammable limit. In addition, the proposed ethylene oxide plant at Fort Saskatchewan, Alberta, is designed to operate within the flammable limit.

APPENDIX A

Critical Factors in Experimental Determination of Flammability Limits

It has generally been concluded that flammability limits are not a fundamental quantity of a material. The experimental apparatus and techniques used can have a profound effect on the measured limits. It is therefore important to identify and define the variables which can affect the measured flammability limits and to adjust the variables so as to minimize their effect on the measured limits.

One important variable is the size of the vessel us d in studying flammability limits. The important factor in choosing the vessel size is the wall cooling effect on the flame propagation. Penner and Mullins (26) suggest vessel diameters greater than 5 cm to avoid this effect. More recently some experimenters have begun to use spherically shaped vessels with the ignition source at the center of the sphere. In this case there is no wall quenching effect since the experiment is complete when the flame front reach s the wall.

A second source of potential error is the direction of flame propagation. A compilation of ethylene flammability by Coward and Jones (27) shows the effect of the direction of flame propagation at ambient temperature and pressure.

The limits determined by the various directions of propagation are shown below.

Direction of Propagation	Lower Limit	Upper Limit
Upward	2.75	34.0
Horizontal	3.20	23.7
Downward	3.33	15.3

The upward propagation of the flame leads to the broadest flammability limits and therefore to the most conservative operating conditions from a safety standpoint.

A third experimental variable which can affect the measured limits is the ignition source. Generally thre types of sources are used: spark, glowing wire, or fused wire. The spark type ignition source, while convenient, can lead to narrower (i.e., less conservative) limits. The glowing wire and fused wire give nearly comparable results. However, the fused wire ignition source is more widely used (see Table 4.0-1). Care must be used in designing the ignition source. If an insufficient ignition source is used, the experiment may define the ignitibility limit rather than a flammability limit.

The criterion used for detecting flame propagation is also important. Atmospheric pressure experiments can be performed in glass apparatus and the flame observed visually.

However, in high pressure bombs other techniques are employed. The two most reliable techniques are changes in pressure upon ignition and depletion of the limiting reagent in the gas mixture. A depletion of the limiting reagent greater than 90% is the criterion for flame propagation used in this study as in earlier studies (5, 6, 7).

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10/23/87

WORST CASE SCENARIO

EQUIPMENT = T-80 ETHYLENE STRIPPER

THE ETHYLENE STRIPPER WILL RUN AT APPROXIMATELY 2 TO 5 PSIG PRESSURE. THE SYSTEM PRESSURE WILL BE CONTROLLED BY FALSE LOADING THE STRIPPED GAS COMPRESSOR, C-1002, WITH NITROGEN, THROUGH PCV 3531 (SEE ATTACHED P&ID).

THE WORST SITUATION THAT CAN OCCUR IN THE PILOT PLANT IS ALLOWING THE STRIPPER TO RUN BELOW ATMOSPHERIC PRESSURE. IF THE COMPRESSOR PULLED A VACUUM ON THE STRIPPER, AIR WOULD FLOW INTO THE COMPRESSOR SUCTION VIA DV-85 DRAIN LINE. THE RESULTANT GAS MIXTURE WOULD THEN BE FLAMMABLE.

PREVENTION: THE ENTIRE PILOT PLANT SYSTEM WILL "SHUT DOWN" UPON PT 3531 SENSING 700 MMHg PRESSURE. THE "SHUT DOWN" IS COMPRISED OF CLOSING ALL FEED GAS AND GAS RETURN EMERGENCY BLOCK VALVES (EBV'S). THEN THE NITROGEN AND VENT EBV'S OPEN ALLOWING NITROGEN TO PURGE THE SYSTEM TO THE ATMOSPHERE. ALSO, ALL MOTORS WILL SHUT DOWN, (i.e. P-104, P-103 AND C-1002), ONCE THE [illegible] IS FOUND, AND CORRECTED, THEN THE PILOT PLANT CAN SAFELY START-UP.

10/26/87 sem

ETHYLENE RECOVERY PILOT PLANT TRIPS. (TO DATE)

1. LOW STRIPPER PRESSURE (700 mm Hg)

PURPOSE: PROTECT SYSTEM FROM ~5% OXYGEN CONCENTRATION. AT 600 mm Hg AIR CAN BE PULLED INTO SYSTEM AND CREATE FLAMMABLE MIXTURE WITH STRIPPER EFFLUENT

2. HIGH LEVEL IN DV-1002

PURPOSE: PROTECT C-1002 (GAS COMPRESSOR) FROM LIQUID ENTERING THE COMPRESSOR SUCTION.

3. C-1002 HIGH DISCHARGE TEMPERATURE

PURPOSE: SHUT SYSTEM DOWN ON LOSS OF COOLING WATER TO C-1002 AFTER COOLER

4. P-001 (SOLVENT CIRCULATION PUMP) LOW FLOW SHUT DOWN

PURPOSE: SHUT SYSTEM DOWN ON LOSS OF SOLVENT FLOW.

5. P-1003 HIGH DISCHARGE TEMP.

PURPOSE: PREVENT PUMP FROM RUNNING DEADHEADED FOR PROLONGED PERIODS.