BIBLIOGRAPHY ON CONTAMINANTS AND SOLUBILITY
OF ORGANIC COMPOUNDS IN OXYGEN

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FOREWORD

The Aerospace Safety Research and Data Institute (ASRDI) was established to support NASA, its contractors, and the aerospace community with technical information and consultation on safety problems. In the process of gathering, evaluating, and applying safety-related information, gaps in the existing safety technology are often noted. Where it appears that progress in filling such gaps can be made through research, ASRDI may undertake or sponsor it. ASRDI also operates a Safety Data Bank of technical information which includes computer files of specialized information sources (organizations) and safety specialists. Current activities are concentrated in the safety implications associated with fire and explosion, cryogenic systems, propellants and other hazardous materials, structural failure, fragmentation, and aircraft systems and operations.

Solomon Weiss, Acting Director
Aerospace Safety Research and Data Institute
National Aeronautics and Space Administration
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INTRODUCTION

A part of the NASA Aerospace Safety Research and Data Institute's (ASRDI) mission is to compile and store in a computerized system bibliographic citations on hazards and safety in various areas related to aerospace activities. One of these areas is Cryogenic Fluids Safety. At the present time the computerized data bank contains about 6500 bibliographic citations on the subject.

Each citation in the data bank contains many items of information about the document. Some of the items are title, author, abstract, corporate source, description of figures pertinent to hazards or safety, key references, and descriptors (keywords) by which the document can be retrieved. In addition, each citation includes an evaluation of the technical contents as to being good/excellent, acceptable or poor. The descriptors used to define the contents of the documents and subsequently used in the computerized search operations were developed for the Cryogenic Fluid Safety by experts in the cryogenics field.

This report is a compilation of a number of document citations, from the Data Bank as of December 1974, which contain information on contaminants in oxygen. A major ASRDI effort has been a review of oxygen safety and a number of special publications summarizing the current state of the art have been published. These include Thermophysical Properties (ref. 1), Temperature Measurements (ref. 2), Flow Measurement Instrumentation (ref. 3), Heat Transfer and Fluid Dynamics (ref. 4), Density and Liquid Level (ref. 5), Characteristics of Metals that Influence Safety (ref. 6), Cleaning Requirements (ref. 7); and Oxygen Systems Engineering Review (ref. 8). Other reports dealing with oxygen safety and research of oxygen systems have also been published (refs. 9 and 10).

The search of the ASRDI Data Bank for information on contaminants in oxygen was initiated after an analysis of liquid remaining after the boil-off of liquid oxygen from a long term oxygen storage tank indicated the presence of aromatic hydrocarbons. Due to the reactivity characteristics of oxygen and possible sources of ignition of contaminants, extensive cleanliness requirements have been utilized (ref. 7). The contaminants, recognized as hazards in oxygen, are identified in most cleanliness requirements as particulate matter, fibers, condensible hydrocarbons, solvent soluble organic residues and solids, and do not usually include considerations of the wide range of organic compounds.

The citations included in the report are present under three separate subject headings:
I. CONTAMINANTS AND SOLUBILITY OF ORGANIC COMPOUNDS IN OXYGEN

II. REACTION CHARACTERISTICS OF ORGANIC COMPOUNDS WITH OXYGEN

III. SAMPLING AND DETECTION LIMITS OF IMPURITIES

In a number of cases, the same citation is referred to in several subject categories.

The report contains, in addition to the citations, an author index and an index of major descriptors. Specific chemical compounds referred to in the citations are also listed in the index.
I. CONTAMINANTS AND SOLUBILITY OF
ORGANIC COMPOUNDS IN OXYGEN
CONTAMINANTS IN LIQUID OXYGEN AS RELATED TO SAFETY IN LIQUID OXYGEN PRODUCTION AND DISTRIBUTION EQUIPMENT

by

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-ABSTRACT-

CONTAMINANTS IN LIQUID OXYGEN ARE CLASSED AS VOLATILES, NON-VOLATILES, AND ACETYLENIC, THE LATTER BEING THE CLASS WITH THE GREATEST HAZARD. THIS CLASS HAS LOW SOLUBILITY IN LIQ AND THEREFORE PRECIPITATES OUT AS A SOLID. IF SUITABLE PRECAUTIONS ARE NOT TAKEN, THESE SOLIDS CAN ACCUMULATE TO DANGEROUS LEVELS IN AIR SEPARATION PLANT EQUIPMENT. THIS DISCUSSION IS LIMITED TO THE CONTAMINANTS INTRODUCED FROM THE AIR PROCESSED IN AIR SEPARATION PLANTS. THE MOST HAZARDOUS AREA IN THE PLANT IS THE MAIN CONDENSER, THE DESIGN OF WHICH SHOULD PREVENT LOCAL ACCUMULATIONS OF SOLIDS. THE SAME IS TRUE OF LIQUID PIPING IN THE PLANT. THERE MUST BE NO TRAPPED POCKETS WHERE LIQUID MAY BOIL AND NON-VOLATILE HYDROCARBONS CONCENTRATE. IN DISTRIBUTION EQUIPMENT, LIQUID OXYGEN IN THE TANK IS NOT PERMITTED TO BOIL OFF TO DRYNESS. VAPORIZERS ARE OPERATED WITH LARGE TEMPERATURE DIFFERENCES TO AVOID DEPOSITION OF SOLID COMBUSTIBLES ON HEAT TRANSFER SURFACES.

-PERTINENT FIGURES-

FIG. 1 MAJOR TYPES OF MAIN CONDENSERS IN LIQUID OXYGEN PLANTS, PAGE 223/
TAB. 1 CLASSIFICATION OF HYDROCARBONS, PAGE 219/
TAB. 2 HYDROCARBONS IN ATMOSPHERIC AIR AT PLANT SITES, PAGE 220/
TAB. 3 HYDROCARBONS IN LIQUID OXYGEN, PAGE 221.

-SOURCE INFORMATION-

CORPORATE SOURCE - LINDE CO., TONAWANDA, N.Y.
JOURNAL PROCEEDINGS - ADVAN. CRYOGEN. ENG., VOL 3, 218-225 (PROC. 1957 CRYOGEN. ENG. CONF.)
PUBLISHER - PLENUM PRESS, INC., N.Y.
OTHER INFORMATION - 0008 PAGES, 0001 FIGURES, 0003 TABLES, 0000 REFERENCES

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STUDY OF LIQUID OXYGEN CONTAMINATION. PROGRESS REPT. NO. 2

by

BAILEY, B. M.
VIGNALLE, V. J.

01/00/60

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-ABSTRACT-

THE OBJECT OF THIS PROGRAM IS THE RECOMMENDATION OF REALISTIC SPECIFICATIONS FOR PROCUREMENT AND USE OF LIQUID OXYGEN FOR ROCKET PROPELLANT SUPPLY SYSTEMS, INCLUDING STANDARDS FOR CLEANLINESS, MONITORING FOR CLEANLINESS AND CONTAMINANTS, AND RECOMMENDATIONS OF DESIGN CRITERIA FOR REDUCTION OF CONTAMINANTS AND INCREASED SAFETY. THIS PROGRESS REPORT DISCUSSES THE SIGNIFICANCE AND SOURCES OF CONTAMINANTS AND THE CHANGES IN QUALITY OF LIQUID OXYGEN IN TRANSIT BETWEEN AIR-Separation Plant Storage and Loading and Unloading the Missile. SOME RECOMMENDATIONS ARE MADE CONCERNING LIQUID TRANSFER PROCEDURE, PIPING ARRANGEMENTS, AND MEANS FOR REMOVAL OF LOW-SOLUBILITY CONTAMINANTS FROM STORED LIQUID OXYGEN.

-PERTINENT FIGURES-

FIG. 1 SIMPLIFIED DIAGRAM, MISSILE OXYGEN SUPPLY AND LOADING SYSTEM, PAGE 12 // FIG. 2 DIFFERENTIAL EVAPORATION OF 99.5 PERCENT LIQUID OXYGEN, PAGE 14 // FIG. 3 TYPICAL LAUNCH-SITE LIQUID OXYGEN STORAGE AND LOADING SYSTEM, PAGE 17 // FIG. 4 EXAMPLES OF PIPING DETAILS RESULTING IN CONTAMINANT CONCENTRATION BUILD-UP, PAGE 19 // FIG. 5 LAUNCH-SITE LIQUID OXYGEN STORAGE FLOW LINES, PAGE 21 // FIG. 6 EFFECT OF VENT VELOCITY AND ATMOSPHERIC DIFFUSION ON OXYGEN CONCENTRATION IN THE VENT LINE - SCHEMATIC, PAGE 23 // FIG. 7 PLANT LIQUID OXYGEN STORAGE TANK - SCHEMATIC, PAGE 26 // FIG. 8 CONTAMINATION CONCENTRATION AS A FUNCTION OF ADSORPTION-PURIFICATION TIME FOR TWO TYPES OF FLOW THROUGH THE STORAGE VESSEL AND THREE RELATIVE PUMPING CAPACITIES, PAGE 33 // FIG. 9 A PROPOSED LIQUID OXYGEN STORAGE TANK ARRANGEMENT FOR MAXIMUM FLUSHING ACTION BY THROUGH-FLOW, PAGE 35 // FIG. 10 AN ARRANGEMENT FOR TRANSFER CONNECTIONS WITH REDUCED CONTAMINANT ADDITION, PAGE 40

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B. M. BAILEY AND V. J. VIGNALLE, RESEARCH STUDY OF LIQUID OXYGEN CONTAMINATION, PROGRESS REPORT NO. 1, AIR PRODUCTS, INCORPORATED.

- Source Information -

Report Number - AD-235063
Contract Number - Contract AF 33(616)-6730
Other Information - 6045 Pages, 0010 Figures, 0020 Tables, 0055 References
HAZARD LEVEL OF HYDROCARBON FILMS IN SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN

KHEAT,E.
08/09/61

SECURITY CLASS: ACCESS LEVEL: REPORT CLASS: ENTRY LEVEL:
Unclassified Unlimited Summary Good/Excel

-ABSTRACT-

The object of this work was to determine realistic standards of cleanliness in systems containing liquid and gaseous oxygen. An arbitrary figure of 4 milligrams per square foot had been previously set by examination of systems that had caused no trouble in the past. It was felt that this figure was too low and that experimental determination of the safe level should be made to set such standards. Based on the experiments reported here, the recommended safe level contamination with hydrocarbons with viscosity and vapor pressure similar to hexadecane is 100 milligrams per square foot.

-PERTINENT FIGURES-

Fig. 1 Ignition Apparatus using gaseous oxygen Page 163/ Fig. 2 Ignition Apparatus using liquid oxygen Page 164/ Fig. 3 Ignition Apparatus using gaseous oxygen Page 164/ Fig. 4 Ignition Apparatus using liquid oxygen Page 165/ Fig. 5 Ignition Apparatus using liquid oxygen after ignition Page 166/ Fig. 6 Unburned hexadecane films after spark ignition in gaseous oxygen Page 166

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JOURNAL PROCEEDINGS -

OTHER INFORMATION -
0007 PAGES, 0008 FIGURES, 0001 TABLES, 0008 REFERENCES
COMPATIBILITY OF LUBRICANTS WITH MISSILE FUELS AND OXIDIZERS

by
FISCHER, K.B.
PHEALE, L.
MESSINA, J.
GITTER, H.

11/00/62

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J/Unrestricted NTIS Summary Acceptable

ABSTRACT


-PERTINENT FIGURES-


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CORPORATE SOURCE - AERONAUTICAL SYSTEMS DIV., WRIGHT-PATTERSON AFB, OHIO. NONMETALLIC MATERIALS LAB. // FRANKFORD ARSENAL, PHILADELPHIA, PA.

REPORT NUMBER - A-62-13/AD-404124


OTHER INFORMATION - 1010 PAGES, 3000 FIGURES, 0012 TABLES, 0011 REFERENCES
CONTAIIINATION OF MISSILE FLUID SYSTEMS.

by

PECKHAM, P.H.

11/00/60

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
J/Unrestricted Unlimited Summary Good/Excel.

-ABSTRACT-

THE AEROSPACE INDUSTRY IS UNIQUE IN ITS STRINGENT REQUIREMENTS REGARDING CONTAMINATION CONTROL. THE REPORT COVERS PROCEDURES, SPECIFICATIONS, ETC. ESTABLISHED BY THE MARTIN COMPANY OVER A NUMBER OF YEARS IN THIS AREA. SPECIFIC AREAS COVERED IN DETAIL INCLUDE DESIGN RECOMMENDATIONS, MANUFACTURING CONTROLS, CLEANING PROCEDURES AND PROCUREMENT RESTRICTIONS (MARTIN HAS ESTABLISHED A CONTAMINATION CONTROLLED PARTS LIST). TABLES ARE PRESENTED ShowING ALLOWED CONTAMINANTS IN LIQUID AND GASEOUS OXYGEN AND NITROGEN, RP-1 AND GASEOUS HELIUM. TABLES ARE ALSO GIVEN SHOWING THE ALLOWED CONTAMINANTS IN SOLVENT RINSES AND VACUUM PROCEDURES. THE CONTAMINANTS SPECIFICALLY COVERED IN THE VARIOUS PROCEDURES AND SPECIFICATIONS ARE HYDROCARBONS (SPECIFICALLY ACETYLENE), FILTERABLE SOLIDS (FILTER SCREEN SIZES ARE GIVEN) AND WATER CONTENT.

-PERTINENT FIGURES-

FIG. 1 AEROSOFT SELF-SEALING COUPLING -- EXTERNAL VIEW, PAGE 30/FIG. 2 AEROSOFT SELF-SEALING COUPLING -- CUTAWAY VIEW, PAGE 31/FIG. 3 HYDROSTATIC TEST FIXTURE -- GENERAL VIEW, PAGE 35/FIG. 4 MISSILE TANK CLEANING CELL, PAGE 36/FIG. 5 DRAWING CALLOUTS, PAGE 42/FIG. 6 COPL FLOW DIAGRAM, PAGE 49/TAB. 1 PROCUREMENT REQUIREMENTS, 327-9020000, PAGE 44/TAB. 2 OPERATIONAL FLUIDS REQUIREMENTS, 327-9020000, PAGE 45/TAB. 3 FINAL SOLVENT RINSE EFFLUENT REQUIREMENTS, 327-9020000, PAGE 46/TAB. 4 VACUUM INSPECTION REQUIREMENTS, 327-9020000, PAGE 47/TAB. 5 TANK FLUSH TEST REQUIREMENTS, 327-9020000, PAGE 48.

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CORPORATE SOURCE - MARTIN CO., DENVER, COLO.
REPORT NUMBER - M-60-39
JOURNAL PROCEEDINGS - SYMPOSIUM ON MATERIALS USED IN AEROSPACE VEHICLE DESIGN, MAY 4-6, 1960, DENVER, COLO.

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0027 PAGES, 0006 FIGURES, 0005 TABLES, 0000 REFERENCES
STUDY OF LIQUID OXYGEN CONTAMINATION, FINAL REPORT.

by

FOSTER, R.H.

05/00/61

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-ABSTRACT-

THIS FINAL REPORT SUMMARIZES THE WORK PERFORMED IN ACCORDANCE WITH CONTRACT AF 33 (516)-6730. THE PURPOSE OF THIS STUDY WAS TO DEVELOP A BETTER UNDERSTANDING OF THE PHYSICAL, CHEMICAL AND MECHANICAL RELATIONSHIPS INVOLVED IN DEVELOPING REALISTIC PARAMETERS FOR SPECIFICATION PURPOSES FOR THE APPLICATION OF OXYGEN TO MISSILES. THE SIGNIFICANT SOURCES AND DEGREE OF CONTAMINATION ARE SUPPLIED AS A BACKGROUND SURVEY AND THE CURRENT (1961) SPECIFICATIONS FOR LIQUID OXYGEN AND GROUND SUPPORT EQUIPMENT ARE DISCUSSED. RECOMMENDATIONS FOR LIQUID OXYGEN SPECIFICATIONS AND FOR EQUIPMENT OPERATION ARE PRESENTED. SOURCES AND MECHANISMS FOR IGNITION OF LIQUID OXYGEN SYSTEMS, FACTORS RELATED TO SOLID CONTAMINANTS, CLEANING AND PURIFICATION OF OXYGEN EQUIPMENT AND HANDLING SYSTEMS HAVE BEEN INCLUDED. AS PART OF THIS STUDY, A THREE-MONTH ANALYTICAL SURVEY WAS MADE AT CAPE CANAVERAL AND SUMMARIZED HERETIN.

-PERTINENT FIGURES-

FIG. 1 SIMPLIFIED DIAGRAM, LIQUID OXYGEN SUPPLY SYSTEM, PAGE 4/FIG. 2 EXAMPLES OF PIPE: DETAILS RESULTING IN CONTAMINANT CONCENTRATION BUILD-UP, PAGE 13/FIG. 3 FLOW LINES IN LIQUID OXYGEN LAUNCH-SITE STORAGE TANK, PAGE 14/FIG. 4 TYPICAL LAUNCH-SITE LIQUID OXYGEN STORAGE AND LOADING SYSTEM, PAGE 15/FIG. 5 SOLUBILITY OF CARBON DIOXIDE IN LIQUID OXYGEN, PAGE 23/FIG. 6 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN, EFFECT ON CONCENTRATION OF MORE VOLATILE CONTAMINANTS, PAGE 25/FIG. 7 SCHEMATIC DRAWING OF APPARATUS USING GASEOUS OXYGEN, PAGE 42/FIG. 8 SCHEMATIC DRAWING OF APPARATUS USING LIQUID OXYGEN, PAGE 43/FIG. 9 FILM IGNITION EQUIPMENT, PAGE 44/FIG. 10 RECOVERY OF HEXADECANE FILMS AFTER SPARK IGNITION IN GASEOUS OXYGEN, PAGE 45/FIG. 11 RECOVERY OF HEXADECANE FILMS AFTER SPARK IGNITION WITH AN ELECTRIC MATCH IN GASEOUS OXYGEN UNDER 200 PSIg PRESSURE, PAGE 46/FIG. 12 RECOVERY OF HEXADECANE FILMS AFTER SPARK IGNITION IN LIQUID OXYGEN, PAGE 47/FIG. 13 APPARATUS FOR EXAMINATION OF SOLID CARBON DIOXIDE FILTERING PHENOMENON, PAGE 52/FIG. 14 EQUIPMENT FOR EXAMINATION OF THE CL(2) FILTRATION EQUIPMENT, PAGE 53/FIG. 15 NEW FILTER ASSEMBLY WITH SIDE TAP, PAGE 54/FIG. 16 DISASSEMBLED FILTER, PAGE 55/FIG. 17 PLASTIC FILTER ASSEMBLY WITH CYLINDRICAL
FILTER ELEMENT (FULL SIZE), PAGE 56/FIG.18 FILTER ASSEMBLY AS MODIFIED WITH SIDE TAKE-OFF FOR HIGH REYNOLDS NUMBER (FULL SIZE), PAGE 56/FIG.19 REYNOLDS NUMBER BEFORE FILTER, PAGE 60/FIG.20 THE VARIATION OF CARBON DIOXIDE AFTER FILTRATION TO REYNOLDS NUMBER IN FILTER ASSEMBLY, PAGE 61/FIG.21 CO(2) CONCENTRATION, PAD 12, PAGE 76/FIG.22 HYDROCARBONS AND VOLUME, PAD 12, PAGE 78/FIG.23 PURITY AND VOLUME, PAD 12, PAGE 80/FIG.24 A PROPOSED LIQUID OXYGEN STORAGE TANK ARRANGEMENT FOR MAXIMUM FLUSHING ACTION BY THROUGH-FLOW, PAGE 96/FIG.25 AN ARRANGEMENT FOR TRANSFER CONNECTIONS TO MINIMIZE CONTAMINANT INTRODUCTION, PAGE 97/TAB.1 OXYGEN CONTAMINANTS ANALYSIS IN REPRESENTATIVE PLANTS, PAGE 18/TAB.2 CONCENTRATION OF DIFFERENT HYDROCARBONS IN REPRESENTATIVE OXYGEN PLANTS, PAGE 20/TAB.3 PARTICULATE MATTER IN LIQUID OXYGEN, PAGE 21/TAB.4 LIQUID OXYGEN INTERIM SPECIFICATIONS, PAGE 27/TAB.6 CLEANLINESS SPECIFICATIONS FOR LIQUID OXYGEN PROPELLANT LOADING SYSTEMS, PAGE 29/TAB.6 CLEANLINESS SPECIFICATIONS FOR LIQUID OXYGEN HARDWARE IN POCKET PROPULSION SYSTEMS, PAGE 30/TAB.7 EXPERIMENTAL RESULTS, PAGE 49/TAB.8 CHRONOLOGY OF STORAGE TANK ACTIVITIES, PAGE 68/TAB.9 SUMMARY OF ANALYTICAL RESULTS, PAGE 71/TAB.10 SAMPLES ASSOCIATED WITH STORAGE TANK ACTIVITIES, PAGE 81/TAB.11 COMPARISON OF DUPLICATE SAMPLES, APCI AND PAFP, PAGE 82.

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STUDY OF LIQUID OXYGEN CONTAMINATION. PROG. REPT. NO. 3

by

BAILEY, B.M.

VITALIS, V.J.

04/00/60

-ABSTRACT-

THE OBJECT OF THIS PROGRAM IS THE RECOMMENDATION OF REALISTIC SPECIFICATIONS FOR PROCUREMENT AND USE OF LIQUID OXYGEN FOR POCKET PROPELLANT SUPPLY SYSTEMS, INCLUDING STANDARDS FOR CLEANLINESS, MONITORING FOR CLEANLINESS AND CONTAMINANTS, AND RECOMMENDATIONS OF DESIGN CRITERIA FOR REDUCTION OF CONTAMINANTS AND INCREASED SAFETY. THIS PROGRESS REPORT RECOMMENDS PROCUREMENT AND USE SPECIFICATIONS FOR TOTAL HYDROCARBONS AND ACETYLENE IN LIQUID OXYGEN. NO SPECIFICATION RECOMMENDATIONS ARE MADE FOR OTHER POSSIBLE CONTAMINANTS FOR LACK OF DEFINITIVE KNOWLEDGE. PROGRAMS FOR OBTAINING THIS INFORMATION HAVE BEEN OUTLINED.

-PERTINENT FIGURES-

FIG. 1 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN - EFFECT ON CONCENTRATION OF LESS VOLATILE CONTAMINANTS, PAGE 15/FIG. 2 SOLUBILITY OF CARBON DIOXIDE IN LIQUID OXYGEN, PAGE 19/FIG. 3 SOLUBILITY OF CARBON DIOXIDE IN GASEOUS OXYGEN, PAGE 21/FIG. 4 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN - EFFECT ON CONCENTRATION OF MORE VOLATILE CONTAMINANTS, PAGE 24/FIG. 5 RELATIONSHIP BETWEEN INITIAL CONTAMINANT CONCENTRATION AND LIQUID OXYGEN VAPORIZATION, PAGE 26/FIG. 6 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN - LIQUID-VAPOR OXYGEN EQUILIBRIUM, PAGE 29/FIG. B-1 CONCENTRATION PROFILES CLOSE TO A SPHERE IMMERSED IN AN INFINITE VOLUME OF SOLVENT, PAGE 41/FIG. B-2 FRACTION DISSOLVED IN TERMS OF DIMENSIONLESS TIME AND DRIVING FORCE, PAGE 43/FIG. B-3 REDUCTION IN DIAMETER AS FUNCTION OF CONTACT TIME AND PARTICLE DIAMETER - CARBON DIOXIDE IN LIQUID OXYGEN, PAGE 46/FIG. B-4 TIME REQUIRED TO DISSOLVE CARBON DIOXIDE PARTICLES IN LIQUID OXYGEN, PAGE 50/TAB. 1 OXYGEN CONTAMINANTS ANALYSES IN REPRESENTATIVE PLANTS, PAGE 12/TAB. 2 CONCENTRATION OF DIFFERENT HYDROCARBONS IN REPRESENTATIVE OXYGEN PLANTS, PAGE 13/TAB. 3 PARTICULATE MATTER IN LIQUID OXYGEN, PAGE 17

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SOURCE INFORMATION

CORPORATE SOURCE
AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

REPORT NUMBER
AD-239516

SPONSOR
CONTAMINATION CONTROL IN LIQUID OXYGEN SYSTEMS.

by

BALL, W.L.

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-ABSTRACT-

This article provides a concise review of contamination in liquid oxygen. Contaminants are classified in terms of solid or dissolved, combustible or inert, and the solubilities of selected saturated and unsaturated hydrocarbons in liquid oxygen is given. Discussion are sources of contamination, means of removal, and concentration effects during storage and handling due to poor equipment design and vaporization.

-RELEVANT FIGURES-

FIG. 1 SOLUBILITY OF SATURATED HYDROCARBONS IN LIQUID OXYGEN PAGE 11/FIG. 2 SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN PAGE 11

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CORPORATE SOURCE -
AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -
CONTAM. CONTR. VOL 3, NO. 8, 10-13 (AUG 1964)

OTHER INFORMATION -
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19

-PERTINENT FIGURES-
FIG. 1 TENSILE AND IMPACT VALUES FOR STEEL AND ALUMINUM, PAGE 24/FIG. 2 COEFFICIENTS OF THERMAL EXPANSION, PAGE 24/FIG. 3 VAPOR PRESSURES OF HYDROGEN, NITROGEN, ARGON, OXYGEN, CARBON DIOXIDE AND WATER, PAGE 25/FIG. 4 DENSITY OF OXYGEN, GASEOUS AND LIQUID, PAGE 25/FIG. 5 THRUST FROM ESCAPING GAS, PAGE 26/FIG. 6 ADIABATIC COMPRESSION TEMPERATURE, PAGE 26

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JOURNAL PROCEEDINGS - CRYOC. SAFETY CONF., PPC. OF, SESSION 2, 23-30, ALLENTOWN, PA., JUL 1959
PUBLISHER - AIR PRODUCTS, INC., ALLENTOWN, PA.
CONTAMINATION IN THE PRODUCTION AND HANDLING OF CRYOGENIC FLUIDS

by

SMITH, C.P.

08/00/64

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-ABSTRACT-

A GENERAL REVIEW OF CONTAMINATION IN THE PRODUCTION OF VARIOUS CRYOGENS. MOST OF THE DISCUSSION COVERS OXYGEN AND NITROGEN IN AIR SEPARATION PLANTS. SOME INFORMATION IS GIVEN FOR HYDROGEN AND HELIUM. THIS IS A BRIEF ARTICLE AND GIVES ONLY GENERAL INFORMATION.

-SOURCE INFORMATION-

CORPORATE SOURCE - LINDE CO., TONAWANDA, N.Y.
JOURNAL PROCEEDINGS - CONTAM. CONTR. VOL 3, NO. 8, 14-56 19632 (AUG 1964)
OTHER INFORMATION - 0006 PAGES, 0000 FIGURES, 0000 TABLES, 0000 REFERENCES
GAS-CHROMATOGRAPHIC METHOD FOR THE DETERMINATION OF POLLUTANTS IN AVIATION LIQUID OXYGEN. (METODO GASCROMATOGRAFICO PER LA DETERMINAZIONE DEGLI INQUINANTI NELL'OSSIGENO LIQUIDO AVIO)

by

CIAVETTI, E.
PECCI, S.
SCUDERI, G.

00/00/65

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Incremental Acceptable

-ABSTRACT-

FOLLOWING AN EXPLANATION OF BASIC PRINCIPLES OF GAS CHROMATOGRAPHY AND SOME TOXICOLOGICAL CONSIDERATIONS OF REASONS FOR REDUCING MAXIMUM ALLOWABLE IMPURITIES IN OXYGEN, THE AUTHORS DESCRIBE A METHOD FOR QUICKLY DETERMINING BOTH ORGANIC AND INORGANIC IMPURITIES. ORGANIC IMPURITIES ARE DETERMINED WITH IONIZING FLAME GAS CHROMATOGRAPHY, INORGANIC ONES WITH A THERMISTOR SENSOR, IN TWO OPERATIONS, AFTER PRECONCENTRATION.

-PERTINENT FIGURES-

FIGS. 1 THRU 4 GAS CHROMATOGRAPHY APPARATUS PAGES 30-1, 34-5//FIGS. 5 THRU 13 CHROMATOGRAPHS OF IMPURITIES IN OXYGEN PAGES 37-42//TABLE MAXIMUM ALLOWABLE CONTAMINANTS PAGE 32.

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OTHER INFORMATION - 0020 PAGES, 0011 FIGURES, 0000 TABLES, 0063 REFERENCES
ANALYSIS FOR TRACE HYDROCARBON CONTAMINANTS IN OXYGEN REBOILERS

by
LINDE, H.W.
SCHAUCH, G.E.

00/00/66

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U/Unrestricted Unlimited Summary Acceptable

-ABSTRACT-

IN CONNECTION WITH A PROGRAM TO STUDY THE CONCENTRATIONS OF HYDROCARBON CONTAMINANTS IN OXYGEN REBOILERS, A GAS CHROMATOGRAPHIC TECHNIQUE WAS DEVELOPED TO MEASURE C(3) THROUGH C(6) HYDROCARBON AT THE 1 TO 15 PART-PER-BILLION LEVEL IN VAPORIZED LOX SAMPLES. THE PROCEDURE CONSISTED OF PASSING A LARGE VOLUME OF OXYGEN (3-15 LITERS) THROUGH A SHORT ALUMINA ADSORPTION COLUMN COOLED TO -78 DEGREES C FOLLOWING WHICH THE ADSORPTION COLUMN WAS SWITCHED INTO A GAS CHROMATOGRAPH CARRIER GAS STREAM. THE COOLANT WAS REMOVED AND THE COLUMN IMMERSED IN WATER AT 95 DEGREES C. THE HYDROCARBON CONTAMINANTS ELUTED FROM THE ADSORPTION COLUMN WERE CHROMATOGRAPHED ON A 12-FOOT DIBUTYL MALATE COLUMN AT 40 DEGREES C. A SINGLE ANALYSIS COULD BE PERFORMED IN 30 MINUTES. THE REBOILERS OF FOUR OXYGEN PLANTS WERE SAMPLED AT WEEKLY INTERVALS OVER A SEVERAL MONTH PERIOD. PROPANE WAS REGULARLY FOUND IN CONCENTRATIONS AS HIGH AS 2300 PPB EACH WHILE THE PENTANES AND HEXANES WERE ORDINARILY BELOW THE DETECTABLE LIMITS BUT OCCASIONALLY ROSE TO THE 20 PPB RANGE.

-PERTINENT FIGURES-

FIG. 1 MODIFIED GAS CHROMATOGRAPH, PAGE 368//FIG. 2 FLOW DIAGRAM, PAGE 368//FIG. 3 CHROMATOGRAM OF STANDARD GAS BLEND, PAGE 370//TAB.1 LIMITS OF HYDROCARBON DETECTION, PAGE 369//TAB.2 HYDROCARBONS IN REBOILER LOX, PAGE 371

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-SOURCE INFORMATION-
SAFETY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN

by

KELLER, E.E.

02/21/57

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REPORT CLASS: Incremental
ENTRY EVAL.: Good/Excel.

-ABSTRACT-

TEST METHOD AND APPARATUS AND TEST RESULTS OF IMPACT SENSITIVITY OF VARIOUS MATERIALS IN LIQUID OXYGEN ARE PRESENTED. ALSO PRESENTED ARE AN ABSTRACT OF A PAPER ON BEHAVIOR OF LIQUID OXYGEN AND A LITERATURE SURVEY OF REACTIONS OF ORGANIC MATERIALS WITH LIQUID OXYGEN. CONCLUSION IS THAT MOST REDUCING AGENTS AND HYDROCARBONS IN CONTACT WITH LIQUID OXYGEN CONSTITUTE A POTENTIAL EXPLOSIVE HAZARD.

-PERTINENT FIGURES-

DRAWING IMPACT TESTER PAGES 17-26 // TABLE 1 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGES 6-10 // TABLE 2 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGES 11 // TABLE 3 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGE 12 // TABLE 4 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGES 12(A)

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REVIEW OF NEW SOLUBILITY DATA FOR CERTAIN HYDROCARBONS IN LIQUID OXYGEN

by

BALL, W.L.

00/00/66

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Incremental Acceptable

-ABSTRACT-

THIS IS A SHORT REPORT ON EXPERIMENTAL MEASUREMENT OF THE SOLUBILITY OF CERTAIN HYDROCARBONS DISSOLVED IN LIQUID OXYGEN. THE SOLUBILITY LIMIT DID NOT CHANGE MEASURABLY FOR 30 TO 90 PSI PRESSURE CHANGE. A DESCRIPTION OF THE TEST APPARATUS IS GIVEN AND RESULTS OF TESTS ARE TABULATED.

-PERTINENT FIGURES-

FIG. 1 LIQUID PHASE SOLUBILITY APPARATUS, PAGE 12/
TAB. 1 LIQUID PHASE SOLUBILITIES IN MOLAR PPM, PAGE 13

-SOURCE INFORMATION-

CORPORATE SOURCE -
AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -
SAFETY IN AIR AND AMMONIA PLANTS, VOL 6, 12-3 (PROC. OF MINNEAPOLIS SYMP. FROM 57TH A.I.CHE. MEETING, SEP 26-9, 1965)

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SAMPLING AND ANALYSIS OF LIQUID OXYGEN, SUPPLEMENT TO SUMMARY PROGRESS REPORT NO. 4

by

SNT, W. L.

07/00/60

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted NTIS Summary Good/Excel.

-ABSTRACT-

This supplemental report to the study of liquid oxygen contamination discusses the sampling techniques and analytical methods which have been used in both the production and use of liquid oxygen. The sampling techniques and analytical methods which are needed and have been established to meet the requirements of several different aspects of the problem, such as, monitoring for oxygen purity, maintenance of combustibles below dangerous concentration levels, control of soluble contaminants, and control of suspended or contained solid. Sampling and analytical techniques which are the most accurate, sensitive, and reliable of those methods discussed, are recommended. The recommended techniques cover purity, total hydrocarbon, carbon dioxide, acetylene, water, and particulates for both production streams, and liquid in storage.

-PERTINENT FIGURES-

FIG. 1 SAMPLING METHODS, PAGES 11, 12, AND 13/FIG. 2 OXYGEN TEST, PAGE 22/FIG. 3 DEW POINT TEMPERATURE OF WATER VAPOR IN AIR, PAGE 29/TAB. 1 SELECTED PHYSICAL-CHEMICAL PROPERTIES OF LIQUID OXYGEN CONTAMINANTS, PAGE 3/TAB. 2 CO(2) CONTAMINATION STUDY AT MARTIN-DEWHEY 75 T/D LIQUID OXYGEN FACILITY, PAGE 16/TAB. 3 TYPICAL CONTAMINANT CONCENTRATIONS IN HIGH PURITY LIOX, PAGE 26

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CORPORATE SOURCE -
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30
STUDY OF LIQUID OXYGEN CONTAMINATION. PROG. RPT. NO. 5

by

Foster, R.H.
Vangelder, W.
Kehat, E.

10/00/60

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
Unclassified NTS Incremental Good/Excel.

-ABSTRACT-

This progress report discusses experimental work done on the filtration of solid carbon dioxide (CO₂) from liquid oxygen and on hydrocarbon film ignition in gaseous oxygen. The equipment and methods used in the experiments are shown and described and the results obtained to date are discussed. It has become obvious that complete filtration of CO₂ flow from liquid oxygen is difficult and extensive work may be required to provide an adequate basis for the recommendation of filter design. Results of the hydrocarbon film tests indicate that the lubricant component n-hexadecane safe film concentration is perhaps 100 mg/sq.ft. rather than 4 mg/sq.ft. as specified at various missile bases. A film thickness of 250 mg/sq.ft. creates a visibly-oily surface, while 500 mg/sq.ft. produces a film having definite flow characteristics. The latter should never be tolerated in any LOX system because films thick enough to flow are capable of accumulating in puddles.

-PERTINENT FIGURES-

Fig. 1 Apparatus for examination of solid carbon dioxide filtering phenomenon, Page 9. // Fig. 7 Plastic filter assembly with cylindrical filter element (full size), Page 15. // Fig. 8 Filter assembly as modified with side take-off for high Reynolds number (full size), Page 15. // Fig. 9 Reynolds number before filter (10 micron pore size) quiescent state, Page 22. // Fig. 10 Reynolds number before filter (10 micron pore size) vibrated filter, Page 23. // Fig. 11 Reynolds number before filter, Page 24. // Fig. 13 Percent recovery of hexadecane after spark ignition, Page 28. // Tab. I Results of CO₂ filtration runs, Page 17. // Tab. II Recovery of n-hexadecane from hydrocarbon ignition tests, Page 29.

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Bailey, B. M. and Vignale, V. J., Study of liquid oxygen contamination, Progress Report No. 1, Dated October 1959, AIR.

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REPORT NUMBER - AD-261738//A.P.I. RESEARCH PROJ. NO. 03-9-2881
SPONSOR - AIR FORCE FLIGHT TEST CENTER, EDWARDS APB, CALIF.
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OPERATIONS FOR SAFETY

by

WCBKEB, B.P.

07/00/59

-ABSTRACT-

Numerous aspects of cryogenic plant safety are reviewed. The importance of plant startup hazards are discussed, with special emphasis being given to using an experienced operating crew, checking emergency equipment, cleaning out initial piping contamination, and the initial operating equipment checkout. Specific topics of plant safety discussed are total hydrocarbon and acetylene contamination, acetylene solubility, and contamination limits, contamination monitoring, Lox storage tank cleaning methods and criteria, and the use of non-sparking tools in oxygen enriched and hydrogen environments. The hazards enumerated are briefly discussed and the existing operating policy of the Air Products Company toward minimizing these hazards is given.

-PERTINENT FIGURES-

TAB. 1 MONITORING FOR CONTAMINANTS PAGE 43

-SOURCE INFORMATION-

CORPORATE SOURCE - AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS - CRYOC. SAFETY CONF., PROC. OF., SESSION 4, 31-3, ALLENTOWN, PA., JUL 1959

PUBLISHER - AIR PRODUCTS, INC., ALLENTOWN, PA.

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SOURCES OF CONTAMINATION, TOLERABLE LIMITS, AND REMEDIAL PROCEDURES

by

BALL, W.L.

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-ABSTRACT-


-PERTINENT FIGURES-

FIG. 1 SOLUBILITY OF SATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 71/FIG. 2 SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 72/FIG. 3 CIRCULATING OXYGEN SYSTEM, PAGE 73/FIG. 4 CIRCULATING OXYGEN SYSTEM, PAGE 74/FIG. 5 SIMPLIFIED FLOW DIAGRAM, TYPICAL HIGH PRESSURE AIR SEPARATION PLANT, PAGE 76/TAB. 1 GAS PHASE FLAMMABLE LIMIT-CARBON ATOM APPROXIMATION, PAGE 79

-SOURCE INFORMATION-

CORPORATE SOURCE - AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.
SAFETY ASPECTS OF RECONSTRUCTED ICI TONNAGE OXYGEN PLANT

by

MATTHEWS, W.D.
OWEN, G.J.

00/00/63

-ABSTRACT-


-PERTINENT FIGURES-

FIG. 9 FINAL DESIGN OF LOX JOINT, PAGE 9/Fig. 10 STRESS VARIATION IN LOX PLANGE BOLTS DURING COOLING CYCLES, PAGE 9

-SOURCE INFORMATION-

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JOURNAL PROCEEDINGS - SAFETY IN AIR AND AMMONIA PLANTS, VOL 5, 1-15 (PROC. CP A SYMP. AT DENVER, COLO, AUG 26-9, 1962)
PUBLISHER - AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, NEW YORK
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SAFETY IN DISPOSAL OF LARGE QUANTITIES OF LIQUID OXYGEN

by

MCMURRAY, T.R.

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-ABSTRACT-

THE MAJOR HAZARD COVERED IN THIS ARTICLE IS ENCOUNTERED BECAUSE OF OXYGEN'S AFFINITY FOR HYDROCARBONS. THE HYDROCARBON HAZARD IS NOT CONFINED TO EXTERNAL SOURCES OF CONTAMINANTS ALONE. THE REASON FOR DISPOSING OF THE LIQUID MAY BE A HIGH HYDROCARBON CONCENTRATION WITHIN THE OXYGEN OF THE MAIN REBOILER ITSELF. THIS PROBLEM IS NOT LIMITED TO THE DISPOSAL OF LIQUID OXYGEN ALONE. IN THE DRAINING OF OXYGEN-RICH LIQUIDS, OR EVEN AIR, SLOW EVAPORATION IN A POT WILL GRADUALLY ENRICH THE OXYGEN CONTENT. OXYGEN PURITIES ABOVE 98 PERCENT ARE READILY ATTAINABLE, AS THE LAST LIQUID VAPORIZES, IF THE BOILING IS SLOW ENOUGH FOR EQUILIBRIUM CONDITIONS TO EXIST. THUS, THE MERE PRESENCE OF NITROGEN IN THE LIQUID DOES NOT ELIMINATE THE HAZARD OR PERMIT CARELESS DISPOSAL TECHNIQUES. ON THE CONTRARY, WHERE TRANSFER LINE GEL TRAPS OR THEIR EQUIVALENT ARE USED, THE OXYGEN-RICH LIQUID TAKEN BEFORE THE TRAPS MAY PRESENT A FAR GREATER DISPOSAL HAZARD THAN THE CLEAN LIQUID OXYGEN FROM THE REBOILER. THIS GREATER HAZARD BEING CREATED BY CONCENTRATING BOTH THE HYDROCARBONS AND THE OXYGEN AS THE LIQUID EVAPORATES. THE FIRST Item IN ANY LIQUID DISPOSAL SYSTEM THAT MUST BE CONSIDERED IS THE DESIGN OF THE LIQUID DRAIN PIPING FROM THE MAIN OXYGEN REBOILER OR OTHER VESSEL TO THE POINT OF LIQUID DISPOSAL. THERE, ARE A FEW GENERAL CONSIDERATIONS TO BE KEPT IN MIND DURING THE DESIGN OF THIS PIPING, AND THESE ARE DISCUSSED. SEVERAL METHODS OF DISPOSING OF THE LIQUID OXYGEN HAVE BEEN TRIED IN THE PAST YEARS INCLUDING THE USE OF LARGE TANKS, GRAVEL-PILED DRAIN PITS, AND VARIOUS STYLES OF HEAT EXCHANGERS. WHILE CLEAN TANKS MAY BE CONSIDERED A SAFE MEANS OF HOLDING THE LIQUID UNTIL IT VAPORIZES FROM NATURAL OR SUPPLIED HEAT SOURCE, UNDER SOME CONDITIONS THE GRADUAL CONCENTRATION OF HYDROCARBONS, PARTICULARLY ACETYLENE, CAN MAKE THIS METHOD POTENTIALLY DANGEROUS. THIS HAZARD IS MORE SERIOUS WITH CONTAMINATED OXYGEN-RICH LIQUIDS SINCE THE SLOW BOILING INCREASES BOTH THE OXYGEN AND HYDROCARBON CONCENTRATIONS. THIS METHOD HAS HAD A FAIRLY GOOD SERVICE RECORD, BUT IT SHOULD BE AVOIDED WHERE POSSIBLE. THE BEST METHOD OF VAPORIZING LIQUID OXYGEN IS IN A VAPORIZER IN WHICH THE OXYGEN IS FLASHED TO GAS AT AMBIENT OR HIGHER TEMPERATURE. THIS ENSURES THAT THE HYDROCARBONS, AND ESPECIALLY ACETYLENE, ARE ALSO VAPORIZED INSTANTANEOUSLY AND CANNOT ACCUMULATE TO HAZARDOUS PROPORTIONS. THE METHOD IS DETAILED IN THIS ARTICLE.
REBOILERS AND VAPORIZERS

by

HUGILL, J.T.
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ANDERSON, C.P.
SIMMS, R.K.
COCHRANE, G.S.
ET AL

05/00/70

ABSTRACT

This is a transcript of an Air Separation Plant Safety Symposium convened at the A.I.Ch.E. National Meeting in St. Paul, Minnesota. Touched on in this short article are contamination limits and analysis, the Navy cryogenic sampler, and some trivial comments on nitrogen oxides in liquid oxygen.

PERTINENT FIGURES

Fig. Details on Sampler Preparation, Page 7

SOURCE INFORMATION

CORPORATE SOURCE


JOURNAL PROCEEDINGS


OTHER INFORMATION

0003 PAGES, 0001 FIGURES, 0000 TABLES, 0000 REFERENCES
SAFE DESIGN AND OPERATION OF LOW TEMPERATURE AIR SEPARATION PLANTS

by

KERRY, F. G.

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-ABSTRACT-

The history of operation of air separation plants for the production of oxygen has been relatively free of explosions and similar such accidents primarily due to careful attention to safe operating practices and safe design of plants. There have been a number of serious accidents and explosions however, particularly in recent years in some of the larger plants that operate continuously. These have been due mostly to excessive levels of acetylene or other hydrocarbon contaminants. Studies have revealed that breakdown of lubricating oils in the compressor or expander and related contamination of the air stream has lead to excessive hydrocarbon levels in the liquid oxygen. Proper plant design and operating procedures can essentially eliminate explosions and accidents in liquid air plants. Included in the paper are safety plant design features, safe operating practices and examples of contamination levels and their control.

-PERTINENT FIGURES-

FIG. 2 ACETYLENE AND HYDROCARBON CONTENT VS WIND DIRECTION, PAGE 5 //FIG. 3 STANDARD PLANT - NO AUXILIARY VAPORIZER, PAGE 7 //FIG. 4 STANDARD PLANT WITH AUXILIARY VAPORIZER, PAGE 8 //FIG. 5 FORCED-FEED, FILM TYPE VAPORIZER, PAGE 6

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THE ROLE OF AIR CONTAMINANTS IN FORMULATING OXYGEN PLANT SAFETY PRINCIPLES

by

MCKINLEY, C.

HINNELBERGER, F.

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-ABSTRACT-

THIS ARTICLE TRACES THE HISTORY OF THE DEVELOPMENT OF AIR SEPARATION PLANTS RELATIVE TO SAFETY FROM EXPLOSIONS DUE TO CONTAMINANTS THAT REACT WITH OXYGEN. A TABLE OF ABOUT 25 COMMON CONTAMINANTS IN AN AIR PLANT SHOWS THE NORMAL BOILING AND FREEZING POINTS. ANOTHER TABLE SHOWING THE SOLUBILITY LIMITS OF MOST OF THESE CONTAMINANTS IS ALSO GIVEN. THE EXPLOSION CHARACTERISTICS AND FLAMMABILITY LIMITS OF SEVERAL OF THE CONTAMINANTS IN LIQUID OXYGEN ARE DISCUSSED. METHODS OF CONTAMINATION LEVEL CONTROL OR REMOVAL ARE MENTIONED. ALSO DISCUSSED ARE METHODS OF PREVENTING EXPLOSIONS. EXPERIMENTAL EXPLOSION TEST DATA IS GIVEN. CONTINUOUS HYDROCARBON ANALYSIS IS RECOMMENDED.

-PERTINENT FIGURES-

FIG. 1 METHANE-LIQUID OXYGEN PHASE SYSTEM, PAGE 11

FIG. 2 ETHANE-LIQUID OXYGEN PHASE SYSTEM, PAGE 11

FIG. 3 EXPLOSION TESTING APPARATUS, PAGE 17

FIG. 4 SCHEMATIC DIAGRAM OF CONTINUOUS TOTAL HYDROCARBON ANALYZER, PAGE 15

FIG. 6 SAMPLE STEP CHART FROM ANALYZER SHOWING OPERATING CYCLE, PAGE 17

TAB. 1 PROPERTIES OF SOME AIR CONTAMINANTS, PAGE 11

TAB. 2 SOLUBILITY OF VARIOUS MATERIALS IN LIQUID OXYGEN, PAGE 11

TAB. 3 GAS PHASE FLAMMABLE LIMIT - CARBON ATOM APPROXIMATION, PAGE 15

TAB. 4 FLAMMABILITY AND DETONABILITY LIMITS - GASES, PAGE 15

TAB. 5 EXPERIMENTAL EXPLOSION TEST DATA, PAGE 14

TAB. 6 TYPE OF CONTAMINANT ANALYSES, PAGE 17

-BIBLIOGRAPHY-

WHEN LIQUID OXYGEN IS STORED, THE ONLY REAL HAZARD IS PRESENTED BY THE GRADUAL ACCUMULATION OF ACETYLENE OVER A LONG PERIOD OF TIME. IF ON-SITE STORAGE TANKS WERE FILLED AND TOPPED OFF WITH LIQUID OXYGEN THAT HAD 0.5 PARTS PER MILLION (PPM) OR LESS ACETYLENE, THE CONTINUOUS INCREASE IN ACETYLENE CONCENTRATION WOULD NOT BECOME HAZARDOUS FOR THREE YEARS. THE EFFECT DEPENDS NOT ON THE SIZE OF THE STORAGE FACILITY, BUT RATHER ON THE HEAT-LEAK LOSSES. THE THREE-YEAR SAFETY PERIOD ASSUMES A HEAT-LEAK LOSS OF 0.4 PERCENT PER DAY. THERE ARE TWO EXCELLENT WAYS TO EXTEND THE PERIOD OF SAFE OPERATION. THE FIRST METHOD PREVENTS ACETYLENE BUILD-UP BY PURIFYING THE LIQUID OXYGEN INTRODUCED INTO THE STORAGE TANK DURING THE TOPPING OPERATION. THE STORAGE TANK SHOULD BE FILLED INITIALLY WITH LIQUID OXYGEN CONTAINING 0.5 PPM OF ACETYLENE. THEREAFTER, EACH MONTHLY ADDITION SHOULD BE PASSED THROUGH A 14-POUND SILICA-GEL BED AT A FLOW RATE OF 730 GPH, THEREBY ELIMINATING ACETYLENE AND ETHYLENE FROM THE ADDED LIQUID OXYGEN. LARGER SILICA-GEL BEDS WOULD OBVIOUSLY PROVIDE HIGHER FLOW RATES. THE SILICA-GEL BED CAN GENERALLY BE ADDED AS AN APPENDAGE TO THE CURRENT LIQUID-OXYGEN LOADING CONNECTIONS. SHOULD THIS PROCEDURE BE USED, THE INITIAL CONCENTRATION OF ACETYLENE WILL NEVER BE INCREASED OR DECREASED. MOREOVER, ONE NEED NOT BE CONCERNED ABOUT EXCESSIVE LOSSES DUE TO BOIL-OFF DURING PURIFICATION, SINCE MOST OF THE LIQUID OXYGEN WOULD BE EITHER IN THE TRAILER OR IN THE STORAGE FACILITY. THE SECOND METHOD USES SMALL QUANTITIES OF FLUORINE. IT IS BELIEVED THAT LESS THAN 0.5 PERCENT OF FLUORINE ADDED TO THE LIQUID OXYGEN ENTERING THE TANK WOULD REACT PREFERENTIALLY WITH ACETYLENE, AND FORM INERT, SOLUBLE PRODUCTS. THE SPECIFIC IMPULSE OF THE FUEL WOULD NOT BE AFFECTED BECAUSE THE FLUORINE WOULD BE USED UP BY CHEMICAL REACTION WITH THE ACETYLENE, AND BY VERY SLOW EVAPORATION WITH THE GASEOUS OXYGEN LOST FROM THE TANK. EXPERIMENTS SHOULD BE CARRIED OUT IN THE LABORATORY TO DECIDE WHETHER THE ADVANTAGES OF TOTAL ELIMINATION OF THE ACETYLENE WOULD OFFSET THE DISADVANTAGES OF HANDLING FLUORINE.

-PERTINENT FIGURES-

FIG. 1 ACCUMULATION OF ACETYLENE IN LOX STORAGE TANKS, PAGE 9
FIG. 2 ACCUMULATION OF ETHYLENE IN LOX STORAGE TANKS, PAGE 10
FIG. 3 POSSIBLE CHROMATOGRAPHIC DETECTION OF CONTAMINANT CONCENTRATION IN STORED LOX, PAGE 14
FIG. 4 DECONTAMINATION OF LOX ON SITE, PAGE 20
TAB. 1 CONTAMINANTS OF INTEREST IN LIQUID OXYGEN, PAGE 5
TAB. 2 POSSIBLE CONCENTRATION OF ACETYLENE, ETHYLENE AND METHANE IN LOX, PAGE 6

-SOURCE INFORMATION-

CORPORATE SOURCE - 46
THE TITLE OF THIS PAPER PRESENT STATUS OF THE HYDROCARBON SITUATION IN AIR SEPARATORS APTLY DESCRIBES ITS CONTENT. AVERAGE AND MAXIMUM VALUES FOUND IN 85 SAMPLES DRAWN FROM THE AIR IN 16 INDUSTRIAL PLANTS ARE GIVEN. IN THE LIGHT OF THESE FIGURES AND RECENT EXPERIENCE IN THE FIELD, THE OPERATION OF AIR SEPARATION PLANTS IN GENERAL IS CONSIDERED TO BE OF HIGHER INHERENT SAFETY THAN PREVIOUSLY THOUGHT. HYDROCARBON CONCENTRATIONS FOR CRITICAL COMPONENTS IN SEVERAL DIFFERENT PLANTS ARE PRESENTED, VAPORIZER AND ADSORBER OPERATIONS AND CHARACTERISTICS ARE DISCUSSED, AND A GOOD REPRESENTATIVE SAMPLING METHOD IS OUTLINED IN THE PAPER.

-PERTINENT FIGURES-

FIG. 1 AIR SAMPLE TAKING IN THE PLANT AREA, PAGE 43//FIG. 2 RECYCLING OF SURPLUS LIQUID FROM AN ADDITIONAL VAPORIZER, PAGE 45//FIG. 3 FILTER AND ADSORBER IN A VAPORIZER CIRCUIT, PAGE 46//FIG. 4 CONCENTRATION BEFORE OF VARIOUS HYDROCARBONS IN GAS PHASE ADSORPTION, 13 DAYS AFTER START, PAGE 46//FIG. 5 SAMPLING ARRANGEMENT FOR LIQUID GASES, PAGE 47//TAB. 1 HYDROCARBON CONCENTRATION IN AIR SAMPLES FROM VARIOUS PLANTS, PAGE 44//TAB. 2 HYDROCARBON CONCENTRATION IN LIQUID AND GASEOUS OXYGEN, PAGE 45

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CORPORATE SOURCE - GESELLSCHAFT FUR LINDES EISMASCHINEN AKTIENGESELLSCHAFT, WEST GERMANY

JOURNAL PROCEEDINGS - SAFETY IN AIR AND AMMONIA PLANTS, VOL 5, 43-7 (1963) (PRES. AT A.I.CHE. NAT. SYMP., 48TH, DENVER, COLO., AUG 26-9, 1962)

OTHER INFORMATION - 0005 PAGES, 0005 FIGURES, 0002 TABLES, 0000 REFERENCES
IN CONSIDERING THE RESULTS OF THE ANALYTICAL PROGRAM, IT IS APPARENT THAT THERE IS MUCH TO BE LEARNED CONCERNING THE CONTAMINANT PROBLEM IN AIR SEPARATION PLANTS. IN PARTICULAR, THERE IS A NEED FOR GREATER KNOWLEDGE OF THE PHYSICAL AND CHEMICAL PROPERTIES OF CONTAMINANTS AT LOW TEMPERATURES, THE EFFECT OR IRREGULAR VARIATION IN PROCESS OPERATION AND THE ABILITY OF PROCESS EQUIPMENT TO MINIMIZE THE EFFECT OF WIDE VARIATIONS IN AIR POLLUTION CONDITIONS. WITH THE CONTINUED IMPROVEMENT OF ANALYTICAL PROCEDURES AND INSTRUMENTATION, A MORE DETAILED APPRAISAL OF THESE PROBLEMS SHOULD BE OBTAINED. FROM THE PRESENT ANALYTICAL STUDY A NUMBER OF GENERAL CONCLUSIONS MAY BE DRAWN. IN PART, THERE IS ALREADY AN APPRECIATION IN THE INDUSTRY OF SOME OF THESE FACTORS.

1. THE EFFICIENCY OF CONTAMINANT REMOVAL BY AIR HEAT EXCHANGERS CANNOT BE PREDICTED SOLELY ON THE BASIS OF CONTAMINANT VAPOR PRESSURE DATA.
2. THE EFFICIENCY OF CATALYTIC FILTERS IS REDUCED AT LOW CONCENTRATIONS.
3. RICH LIQUID SILICA GEL FILTERS ARE VERY EFFECTIVE IN REMOVING SMALL QUANTITIES OF ACETYLENE BUT ARE ONLY PARTIALLY EFFECTIVE IN REMOVING C(3)-C(5) PARAFFINS. THEIR EFFECTIVENESS FOR THE LATTER IS FURTHER REDUCED BY THE PRESENCE OF LARGE AMOUNTS OF CARBON DIOXIDE AND NITROUS OXIDE ON THE FILTER.
4. THERE IS CONSIDERABLE PROBABILITY THAT SOLID ACCUMULATIONS OF CONTAMINANTS WILL OCCUR ON THE WALLS OF VAPORIZERS EVEN THOUGH THE AVERAGE CONCENTRATION IN THE BULK LIQUID PHASE IS WELL BELOW THE SOLUBILITY LIMIT. IN THE CASE OF AUXILIARY VAPORIZERS, SIGNIFICANT QUANTITIES MAY BE DEPOSITED AT QUITE LOW INTAKE CONCENTRATIONS OVER A ONE-MONTH PERIOD. THIS EMPHASIZES THE NEED FOR REGULAR DERIVING OF THESE UNITS.

-PERTINENT FIGURES-

FIG. 1 WEEKLY VARIATION OF CONTAMINANTS ON RICH LIQUID FILTER, PAGE 39
TAB. 1 CONCENTRATION OF CONTAMINANTS IN PROCESS STREAMS, PAGE 40
TAB. 2 CONTAMINANTS HELD ON WALLS OR REGENERATORS (EXCLUDING H(2)O AND CO(2)), PAGE 40
TAB. 3 CONTAMINANTS HELD ON WALLS OF MAIN VAPORIZER, PAGE 41
TAB. 4 CARBON DIOXIDE AND NITROUS OXIDE DERIVED, PAGE 41
TAB. 5 ACETYLENE AND OXIDES OF NITROGEN DERIVED, PAGE 42
TAB. 6 C(3)-C(5) HYDROCARBONS DERIVED, PAGE 42
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OXYGEN PLANT VAPORIZER EXPLOSION

by

WRIGHT, G.T.

04/00/61

-ABSTRACT-


-PERTINENT FIGURES-

TAB. 1 ACETYLENE CONTAMINANT LEVELS IN PLANT OPERATION, PAGE 11
TAB. 2 CONTAMINANTS ON THE RICH-LIQUID AND LIQUID OXYGEN FILTERS IN NO. 2 AND NO. 3 PLANTS, PAGE 11

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JOURNAL PROCEEDINGS - CHEM. ENG. PROG., VOL 57, NO. 4, APR 1961 (PRESENTED AT TULSA SYMP OF A.I.CHE. IN TULSA, OKLA., SEP 25-8, 1960 REPRINTED IN AIR AND AMMONIA PLANTS, VOL 3, 9-12)
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51
SAFETY ASPECTS OF MODERN AIR SEPARATION PLANT CYCLES

by

KERRY, F. G.

04/00/57

SECURITY CLASS Access Level Report Class Entry Eval.
U/Unrestricted Unlimited Summary Acceptable

-ABSTRACT-

This paper briefly describes some of the modern air separation plant cycles such as the medium pressure, low pressure and high pressure cycles relative to safety in design and operation. Particular emphasis is placed on the control and removal of contaminants that could react with oxygen if the concentration levels become excessive. The solubility of hydrocarbons and acetylene are illustrated. The use of silica gel filters for contaminant removal is described.

-PERTINENT FIGURES-

FIG. 1 SCHEMATIC FLOW DIAGRAM OF A STANDARD MEDIUM PRESSURE AIR SEPARATION PLANT, PAGE 181/FIG. 2 SCHEMATIC FLOW DIAGRAM OF A STANDARD LOW PRESSURE AIR SEPARATION PLANT, PAGE 182/FIG. 3 SOLUBILITY OF ACETYLENE IN LIQUID OXYGEN AND NITROGEN, PAGE 183/FIG. 4 ACETYLENE REMOVAL CAPACITY OF SILICA GEL FILTERS CONTAMINATED WITH FOREIGN MATTER, PAGE 183/FIG. 5 SCHEMATIC FLOW DIAGRAM OF A HIGH PRESSURE AIR SEPARATION PLANT, PAGE 183/FIG. 6 SCHEMATIC FLOW DIAGRAM OF THE DOUBLE CYCLE AIR SEPARATION PLANT, PAGE 184/FIG. 7 FREQUENCY DISTRIBUTION CURVE FOR SOLUBILITY OF VARIOUS HYDROCARBONS IN OXYGEN, PAGE 183

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CORPORATE SOURCE - AMERICAN AIR LIQUIDE, INC., NEW YORK, N.Y.
JOURNAL PROCEEDINGS - CHEM. ENG. PROGR. VOL 53, NO. 4, 181-4 (APR 1957) (REPRINTED IN SAFETY IN AIR AND AMMONIA PLANTS VOL 1, 20-3)
RESEARCH STUDY OF LIQUID OXYGEN CONTAMINATION, PROG. REPT.

by

BAILEY, B.H.
VIGNALE, V.J.

10/00/59

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-ABSTRACT-

(Unclassified) The object of this program is the recommendation of realistic specifications for procurement and use of liquid oxygen in missile oxygen-supply-systems. These specifications will be based on the analysis of existing knowledge and the development of further information concerning the relationships between the missile oxygen-supply-system functions and the liquid oxygen purity. Each step in the missile oxygen-supply-system from the generation of the liquid oxygen to its final use in the missile is being studied to determine the controlling factors. This progress report discusses the combusted contaminants introduced during the generation of liquid oxygen and analyzes the problems associated with the flammable nature of these contaminants.

-PERTINENT FIGURES-

FIG. 1 BASIC FUNCTIONS IN LCX SUPPLY OPERATIONS, PAGE 11
FIG. 2 FLOW DIAGRAM OF A LIQUID OXYGEN GENERATOR, PAGE 17
FIG. 3 SOLUBILITY OF SATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 28
FIG. 4 SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 29
TAB. 1 SOME GASES AND VAPORS WHICH MAY BE PRESENT IN THE AIR FEED OF LIQUID OXYGEN GENERATORS, PAGE 14
TAB. 2 PROPERTIES OF POSSIBLE INGREDIENTS OF AIR, PAGE 15

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COMPOSITION AND ANALYSIS OF COMMERCIAL LIQUID OXYGEN

by

SMITH, C.P.

00/00/60

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Summary Good/Excel.

-ABSTRACT-

FOREIGN MATERIALS IN LIQUID OXYGEN NORMALLY COME FROM THE ATMOSPHERE AND FROM THE PRODUCTION PROCESS WHERE IT IS NOT ECONOMICALLY FEASIBLE TO COMPLETELY REMOVE THEM. THIS ARTICLE SETS FORTH THE COMPOSITION OF COMMERCIAL LIQUID OXYGEN AND DESCRIBES METHODS OF PURIFICATION AND ANALYSIS.

-PERTINENT FIGURES-

TAB. 2 MAXIMUM LIMITS OF CONTAMINANTS FOR BREATHING OXYGEN LIQUID AND MISSILE PROPELLANT OXYGEN, PAGE 546

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ICEY 5769

OXYGEN, AVIATORS BREATHING, LIQUID AND GAS

-ABSTRACT-

THIS SPECIFICATION CLEVELS LIQUID AND GASEOUS AVIATORS BREATHING OXYGEN. INCLUDED ARE A LISTING OF OTHER APPLICABLE DOCUMENTS (SPECIFICATIONS AND STANDARDS), A TABLE OF MAXIMUM PERMISSIBLE CONTAMINANT CONCENTRATIONS, A TABLE LISTING OXYGEN CYLINDER FILL PRESSURES FOR VARIOUS TEMPERATURES, AND INSPECTION, SAMPLING AND TESTING REQUIREMENTS AND PROCEDURES.

-PERTINENT FIGURES-

FIG. 1 FILTER, CRYOGENIC LIQUIDS PAGE 23/TAB. 1 CONSTITUENT CONCENTRATIONS PAGE 3/TAB. 2 TYPE I OXYGEN CYLINDER FILL PRESSURE FOR VARIOUS TEMPERATURES PAGE 9/TAB. 3 TEST SAMPLES PAGE 14

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MILITARY SPECIFICATION MIL-V-2, VALVE CYLINDER, GAS (FOR COMPRESSED OR LIQUEFIED GASES) GENERAL SPECIFICATION FOR/ MILITARY SPECIFICATION MIL-D-3716, DESICCANTS, ACTIVATED FOR DYNAMIC DEHUMIDIFICATION/MILITARY SPECIFICATION MIL-L-25567, LEAK TEST COMPOUND, OXYGEN SYSTEMS/MILITARY SPECIFICATION MIL-T-27730, TAPE, ANTISEIZE, TETRAFLUOROETHYLENE, WITH DISPENSER/MILITARY STANDARD MIL-STD-131, COLOR CODE FOR PIPELINES AND FOR COMPRESSED GAS CYLINDERS/MILITARY STANDARD MIL-STD-129, MARKING FOR SHIPMENT AND STORAGE

-SOURCE INFORMATION-

CORPORATE SOURCE - AERONAUTICAL STANDARDS GROUP, SILVER SPRING, MARYLAND
REPORT NUMBER-- MIL-O-27210D (ASG)
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57
OXYGEN SPECIFICATION

-ABSTRACT-

THIS STANDARD IS FOR PROCUREMENT OF LIQUID AND GASEOUS OXYGEN AND IS APPLICABLE TO MSPC AND ITS CONTRACTORS. THREE GRADES ARE SPECIFIED, A-FOR FUEL CELLS, B-FOR BREATHING AND C-FOR PROPPELLANTS. ALLOWED CONTAMINANT LEVELS ARE SPECIFIED FOR EACH GRADE FOR SEVERAL SPECIFIC DISSOLVED AND SOLID CONTAMINANTS.

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CORPORATE SOURCE - NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.
REPORT NUMBER - MSFC-SPEC-399A
OTHER INFORMATION - 0013 PAGES, 0000 FIGURES, 0003 TABLES, 0005 REFERENCES
STUDY OF LIQUID OXYGEN CONTAMINATION, SUMMARY PROGRESS REPORT NO. 4

by

BAILY, B. M.

STERNE, C. J.

VIGNALE, V. J.

07/00/60

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J/Unrestricted NTIS Summary Good/Excel.

-ABSTRACT-

THIS SUMMARY PROGRESS REPORT NO. 4 PRESENTS A REVIEW OF THE WORK PERFORMED IN ACCORDANCE WITH CONTRACT AF 33(616) - 6730. THE PURPOSE OF THIS STUDY IS TO DEVELOP A BETTER UNDERSTANDING OF THE PHYSICAL-CHEMICAL AND MECHANICAL RELATIONSHIPS INVOLVED AND TO DEVELOP REALISTIC PARAMETERS FOR SPECIFICATION PURPOSES FOR THE APPLICATIONS OF OXYGEN TO MISSILES. THE SIGNIFICANCE, SOURCES, AND DEGREE OF CONTAMINATION, AND THE CURRENT SPECIFICATIONS FOR LIQUID OXYGEN AND EQUIPMENT ARE DISCUSSED. RECOMMENDATIONS FOR LIQUID OXYGEN SPECIFICATIONS AND FOR EQUIPMENT OPERATION ARE PRESENTED. AN EXTENSIVE BIBLIOGRAPHY IS INCLUDED, AS WELL AS APPENDICES WHICH AMPLIFY THE GENERAL DISCUSSION.

-PERTINENT FIGURES-

FIG. 1 SIMPLIFIED DIAGRAM, LIQUID OXYGEN SUPPLY SYSTEM, PAGE 8/FIG. 2 EXAMPLES OF PIPING DETAILS RESULTING IN CONTAMINANT CONCENTRATION BUILD-UP, PAGE 12/FIG. 3 FLOW LINES IN LIQUID OXYGEN LAUNCH-SITE STORAGE TANK, PAGE 13/FIG. 4 TYPICAL LAUNCH-SITE LIQUID OXYGEN STORAGE AND LOADING SYSTEM/FIG. 5 SOLUBILITY OF CARBON DIOXIDE IN LIQUID OXYGEN, PAGE 22/FIG. 6 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN, EFFECT ON CONCENTRATION OF MORE VOLATILE CONTAMINANTS, PAGE 24/Fig. 7 A PROPOSED LIQUID OXYGEN STORAGE TANK ARRANGEMENT FOR MAXIMUM FLUSHING ACTION BY THROUGH-FLOW, PAGE 38/FIG. 8 AN ARRANGEMENT FOR TRANSFER CONNECTIONS TO MINIMIZE CONTAMINANT INTRODUCTION, PAGE 39/FIG. 9 FLOW DIAGRAM OF A LIQUID OXYGEN GENERATOR, PAGE 49/FIG. 10 SOLUBILITY OF SATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 56/FIG. 11 SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 57/FIG. 12 TEMPERATURE DISTRIBUTION IN TYPICAL VENT LINE, PAGE 64/FIG. 13 DIFFERENTIAL ELEMENT OF VENT LINE FOR ANALYSIS, PAGE 65/FIG. 14 VENT-LINE AXIAL CONCENTRATION PROFILES NEAR THE ORIGIN, PAGE 70/FIG. 15 VENT-LINE AXIAL CONCENTRATION PROFILES NEAR THE ORIGIN, PAGE 70/FIG. 16 SCHEMATIC DIAGRAM OF EXPERIMENTAL SET-UP FOR BACK-DIFFUSION STUDIES, PAGE 74/FIG. 17 SAMPLING PROBE FOR RADIAL CONTAMINANT CONCENTRATION MEASUREMENTS, PAGE 75/FIG. 18
CORPORATE SOURCE - AIR PRODUCTS INC., ALLENTOWN, PA.

REPORT NUMBER - AD-253231

SPONSOR - AIR FORCE FLIGHT TEST CENTER, EDWARDS AFB, CALIF.

CONTRACT NUMBER - CONTRACT AP 33(616)-673C

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MATERIALS FOR LUBRICATING AND SEALING PROPELLANT AND HOT-GAS SYSTEMS

by

KERITULA, JR. E. F.

05/00/64

-ABSTRACT-

THIS REPORT IS INTENDED TO AID DESIGN PERSONNEL IN THE SELECTION OF LUBRICANTS AND THREAD SEALANTS FOR GASEOUS AND LIQUID O(2)/H(2) SERVICE. THREAD LUBRICANTS, SEALANTS, AND THREADING COMPOUNDS LISTED IN THIS REPORT ARE THOSE MATERIALS WHICH ARE APPLIED TO CONNECTIONS OR THREADED FITTINGS FOR PREVENTING SEIZING OR GALLING DURING ASSEMBLY AND FOR MINIMIZING LEAKAGE IN USE. THREAD SEALANTS ARE DEFINED HEREIN AS MATERIALS WHICH DO NOT NORMALLY HARDEN OR SET AND ARE USED IN NONPERMANENT APPLICATIONS. THREADING COMPOUNDS ARE THOSE WHICH HARDEN AND ARE USED FOR PERMANENT-TYPE JOINTS. THREAD LUBRICANTS ARE FOR NONSEALING INSTALLATIONS. NATURALLY, THE FACTORS TO BE CONSIDERED IN THE FINAL SELECTION OF ANY MATERIAL ARE DEPENDENT UPON THE SERVICE INTENDED. SELECTION AND EVALUATION OF THESE FACTORS WILL VARY WIDELY. THUS, THIS REPORT DOES NOT ATTEMPT TO PROVIDE ALL INFORMATION NECESSARY TO FULLY ASSESS THE ADEQUACY OF A MATERIAL FOR SPECIFIC APPLICATIONS.

-PERTINENT FIGURES-

TAB.1 CHLOROFLUOROCARBON OILS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGES 7-8/TAB.2 CHLOROFLUOROCARBON GREASES, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGES 9-10/TAB.3 VARIOUS INERT FLUIDS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGE 11/TAB.4 VARIOUS INERT GREASES, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGE 12/TAB.5 CHLORINATED HYDROCARBON THREAD SEALANTS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGE 13/TAB.6 CHLOROPHLOFOROCARBON THREAD LUBRICANTS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGE 14/TAB.7 TETRAFLUOROETHYLENE THREAD SEALANTS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGE 14/TAB.8 INORGANIC THREADING COMPOUNDS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGE 15/TAB.9 DRY FILM LUBRICANTS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGES 16-17/TAB.10 BONDED SOLID FILM LUBRICANTS, ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGE 18/TAB.11 HIGH-TEMPERATURE ANTISEIZE COMPOUNDS, ACCEPTABLE FOR HOT-GAS SYSTEM LUBRICATION, PAGE 19/TAB.12 VARIOUS MATERIALS USED AS THREAD COMPOUNDS, LUBRICANTS, AND SEALANTS, NOT ACCEPTABLE FOR LIQUID AND GASEOUS OXYGEN SYSTEMS, PAGES 20-22
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REPORT NUMBER - 64-298//AD-448155
OTHER INFORMATION - 0028 PAGES, 0000 FIGURES, 0013 TABLES, 0007 REFERENCES

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SAFETY ASPECTS IN THE DESIGN AND OPERATION OF OXYGEN SYSTEMS

by

REYNALD, C.H.

01/00/59

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-ABSTRACT-

This paper deals with the behavior and properties of oxygen as they apply to safety aspects in the design and operation of the oxygen transfer system of the Thor missile. The paper summarizes the findings of a study on the compatibility of materials with oxygen, lists the results of various tests performed to determine the resistance of materials and contaminants to ignition in an oxygen atmosphere, and reviews the observations from a field survey made among the organizations most actively engaged in the production and use of oxygen. The overall conclusion from this project is that oxygen is a potential explosive which should be handled with care. There are three basic elements required for combustion, one of which is oxygen. The other two are the combustible materials and the sources of energy needed to induce a reaction. Until we learn more about the first element, oxygen, it is necessary to control the other two. This can be done by reducing or eliminating the sources of energy throughout a system and by a cleaning and maintenance program aimed at the elimination and avoidance of contaminants.

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HANDLING OF LOW-TEMPERATURE FLUIDS AND HIGH-PRESSURE OXYGEN

by

HIMMEZBERGER, F.

10/00/59

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-ABSTRACT-

HAZARDS ASSOCIATED WITH CRYOGENIC FLUIDS ARE BROKEN DOWN INTO FOUR CATEGORIES, 1. PERSONNEL EXPOSURE TO EXTREME COLD OR TO INERT OR TOXIC GASES. 2. BRITTLENESS OF STRUCTURAL MATERIALS AT LOW TEMPERATURES. (THIS MAY NOT BE A HAZARD IN ITSELF BUT CAN CONTRIBUTE TO PERSONNEL EXPOSURE OR TO THE FORMATION OF FLAMMABLE MIXTURES.) 3. HIGH PRESSURE ARISING FROM CONFINEMENT OF LIQUIDS AND GASES. 4. FLAMMABILITY CHARACTERISTICS. THIS PAPER CONCENTRATES ON NUMBER 4, SINCE THE ELIMINATION OF UNINTENTIONAL FLAMMABLE MIXTURES IS THE MOST SERIOUS PROBLEM.

-PERTINENT FIGURES-

FIG. 1 METHANE-OXYGEN-NITROGEN FLAMMABILITY LIMITS//FIG. 2 FLAMMABILITY AND DETONABILITY LIMITS - GASES//FIG. 3 SOLUBILITY OF HYDROCARBONS IN LIQUID OXYGEN//FIG. 4 CARBON ATOM CONTENT VERSUS SOLUBILITY FOR SATURATES//FIG. 5 ADIABATIC COMPRESSION TEMPERATURE//FIG. 6 ADSORPTION OF ETHYLENE, ETHANE AND METHANE//FIG. 7 FLAMMABLE LIMITS IN AIR

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JOURNAL PROCEEDINGS - AERONAUT. IND. SECTION PROG. OF THE NATIONAL SAFETY CONGR., CHICAGO, ILL., OCT 19, 1959
OTHER INFORMATION - 0016 PAGES, 0009 FIGURES, 0000 TABLES, 0000 REFERENCES

67
SURVEY OF ACCIDENTS AT THE AIR SEPARATION PLANTS

-ABSTRACT-

A LARGE NUMBER OF ACCIDENTS WHICH OCCURRED IN AIR SEPARATION PLANTS IN JAPAN AND ELSEWHERE ARE ANALYZED. CLAUDE-TYPE, LINDE-TYPE, AND FRANKEL-TYPE SEPARATION PLANTS ARE DISCUSSED. ACCIDENTS WERE CLASSIFIED INTO EXPLOSIONS, BURSTING ACCIDENTS AND ACCIDENTS IN WHICH HUMANS WERE INJURED OR KILLED. VARIOUS ACCIDENT MODES ARE ANALYZED, AND THE SUCCESS OF APPROPRIATE COUNTERMEASURES IS DESCRIBED. DATA ON ALL AIR SEPARATION PLANTS IN JAPAN ARE GIVEN. MANY SAFETY RECOMMENDATIONS ARE GIVEN THROUGHOUT THE REPORT.

-PERTINENT FIGURES-


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REPORT NUMBER - N71-12657//NASA-TT-F-13388
JOURNAL PROCEEDINGS - J. AMMONIUM SULPHATE ENG. VOL 17, NO. 3, (1964) (TRANSL. BY SCIENTIFIC TRANSLATION SERVICE, DEC. 1970)
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HIGH-PURITY PRODUCTS FROM AN AIR SEPARATION PLANT

by

DINAPOLI, R.N.
SASS, A.M.

00/00/70

-ABSTRACT-

THE SIMULTANEOUS PRODUCTION OF HIGH PURITY OXYGEN, NITROGEN, AND ARGON IS OFTEN REQUIRED FROM AIR SEPARATION PLANTS TO MEET TODAY'S NEEDS OF THE MILITARY, SPACE, AND COMMERCIAL MARKETS. DETAILED PRODUCT SPECIFICATIONS AS DEVELOPED BY THE VARIOUS SEGMENTS OF THE INDUSTRY ARE PRESENTED TOGETHER WITH ACTUAL PLANT PERFORMANCE DATA. GAS CHROMATOGRAPHY IS USED TO MEASURE INDIVIDUAL COMPONENT IMPURITIES IN OXYGEN AND TO MONITOR HYDROCARBON CONTENT AT VARIOUS LOCATIONS WITHIN THE PLANT.

-PERTINENT FIGURES-

TAB. 1 TYPICAL HIGH PURITY PRODUCT SPECIFICATIONS PAGE 10/TAB. 3 GAS CHROMATOGRAPHIC ANALYSIS PAGE 12

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70
SAFETY PRECAUTIONS WITH RESPECT TO HYDROCARBONS IN AIR
FRACTIONATING APPARATUS (SCHUTZMASSNAKEM GEGEN
KOHLENWASSERSTOFFE IM LUFTTRENKEN)

by

KARWATE

11/00/60

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U/Unrestricted Unlimited Incremental Good/Excel.

-ABSTRACT-

This reports the investigation of an explosion in the Linde-Franzl apparatus in an air separation plant. The explosion took place when liquid oxygen from the acetylene separator was discharged. Previous tests showed that the acetylene content of the stream was less than 0.01 ppm so that the explosion must have been caused by other hydrocarbons. It appears that the propylene present in the stream prevents the sorption of ethane and impairs the sorption of propane and ethylene. The author recommends: 1) More vigorous flushing of the auxiliary vaporizer, with the return of the overflow liquid through the adsorber placed ahead of the auxiliary vaporizer. 2) Scrubbing out of the hydrocarbons from the air with the smallest possible amount of liquid air before its entrance into the column. 3) Adsorption of the hydrocarbons from the gaseous air between the regenerator and the column. 4) Regenerative adsorption/desorption of the air on a sorbent layer placed at the cold end of the regenerator. 5) Burning of the hydrocarbons before the air enters the fractionator. The paper includes details for implementing the recommendations.

-PERTINENT FIGURES-

FIG. 1 ADSORPTION OF VARIOUS HYDROCARBONS ON SILICA GEL FROM THEIR SOLUTION IN LIQUID OXYGEN, PAGE 13
FIG. 2 FLUCTUATIONS IN THE PROPANE CONTENT OF THE LIQUID IN THE PRESSURE COLUMN AND IN THE MAIN CONDENSER, PAGE 14
FIG. 3 ADSORBER FOR THE OVERFLOW LIQUID FROM THE AUXILIARY VAPORIZER, PAGE 15
FIG. 4 TEMPERATURE CHANGES IN THE GEL LAYER REGENERATOR, PAGE 16

-SOURCE INFORMATION-

CORPORATE SOURCE - PULLACH NEAR MUNICH
JOURNAL PROCEEDINGS - LINDE BER. TECH. WISS., NO. 10, 12-6 (NOV 1960) (IN GERMAN) (TRANSLATED) BY F.E.E. GERMANN, NBS, TRANS. NO. T-14, APR.
THE DETERMINATION OF TRACE IMPURITIES IN LIQUID OXYGEN FOR BREATHING BY INFRA-RED METHODS

by

CORBETT, J.K.

10/00/67

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-ABSTRACT-

A DOUBLE-BEAM INFRA-RED SPECTROPHOTOMETER HAS BEEN MODIFIED BY THE ADDITION OF A PAIR OF 40 METRE LONG-PATH CELLS AND ORDINATE SCALE EXPANSION TO MAKE POSSIBLE THE DETECTION AND QUANTITATIVE DETERMINATION OF TRACES OF IMPURITIES IN LIQUID OXYGEN FOR BREATHING. THE EFFECTS OF PRESSURE BROADENING ARE CONSIDERED AND THE LOWER LIMITS OF DETECTION ARE LISTED FOR THE IMPURITIES DETERMINED. THIS SPECTROPHOTOMETER PROVIDES AN ACCURATE AND RAPID METHOD FOR THE DETERMINATION OF THE TRACES IMPURITIES IN LIQUID OXYGEN FOR BREATHING TO AIR STANDARD 14/9A. ONLY INFRARED INACTIVE MOLECULES SUCH AS NITROGEN, HELIUM, ARGON, ETC. ARE INCAPABLE OF DETECTION BY THE METHOD DESCRIBED.

-PERTINENT FIGURES-

TAB.1 SPECTROSCOPIC DATA FOR IMPURITIES, PAGE 4/TAB.2 PRESSURE BROADENING OF A CONSTANT PARTIAL PRESSURE OF ETHYLENE, PAGE 5/TAB.3 PRESSURE SENSITIVITY, PAGE 6/TAB.4 CALIBRATION DATA FOR GASES, PAGE 10/TAB.5 MINIMUM DETECTION LIMITS, PAGE 13/TAB.10 CONCENTRATIONS OF IMPURITIES FOUND IN OXYGEN, PAGE 14

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LIQUID PROPELLANT GAS ABSORPTION STUDY, FINAL SUMMARY TECH.
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by
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ENGLISH, W. D.

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-ABSTRACT-

THIS FINAL TECHNICAL REPORT SUMMARIZES THE STUDIES CONDUCTED ON THE SOLUBILITIES OF PRESSURANT GASES HELIUM AND NITROGEN IN THE LIQUID PROPELLANTS FLUORINE, FLOX, OXYGEN, OXYGEN DIFLUORIDE, OXYGEN DIFLUORIDE, NITROGEN TRIFLUORIDE, TETRAFLUOROHYDRAZINE, CHLORINE TRIFLUORIDE, CHLORINE PENTAFLUORIDE, ETHANE, ETHYLENE, PROPANE, LEBORANE, TRIMETHYLBORANE, NITRYL FLUORIDE, PERCHLORYL FLUORIDE, AND AMMONIA. HELIUM SOLUBILITIES WERE MEASURED FOR ALL PROPELLANTS, BUT ONLY A FEW COMBINATIONS WERE USED WITH NITROGEN. MEASUREMENTS WERE MADE AT TWO PRESSURES, 300 AND 700 PSIG, AND AT SEVERAL APPROPRIATE TEMPERATURES COVERING A RANGE ABOVE AND BELOW THE NORMAL BOILING POINT WHEREVER POSSIBLE. SAMPLES WERE TAKEN FROM CAREFULLY EQUILIBRATED, AGITATED SYSTEMS, AND ANALYSES WERE CONDUCTED BY GAS CHROMATOGRAPHY. THE GAS CHROMATOGRAPHIC ANALYSES OF THE HIGH ENERGY PROPELLANTS REQUIRED THE APPLICATION OF SEVERAL UNCONVENTIONAL TECHNIQUES. THESE INCLUDED (1) USE OF OXYGEN AS A CARRIER GAS, AND (2) COMPLETE ABSORPTION OF THE PROPELLANT ON THE COLUMN TO PREVENT ATTACK ON THE DETECTOR SENSORS, YET PERMITTING ELLUTION OF OTHER COMPONENTS, INCLUDING THE PRESSURANT GAS, FOR ACCURATE ANALYSES.

-PERTINENT FIGURES-
TAB.2 SOLUBILITY OF HELIUM AND NITROGEN IN LIQUID OXYGEN DIFLUORIDE, PAGE 24/TAB.5 SOLUBILITY OF HELIUM IN LIQUID FLUORINE, PAGE 30/TAB.7 SOLUBILITY OF HELIUM IN LIQUID 7O-FLOX, PAGE 33/TAB.9 SOLUBILITY OF HELIUM IN LIQUID OXYGEN, PAGE 36/TAB.11 SOLUBILITY OF HELIUM AND NITROGEN IN LIQUID ETHYLENE, PAGE 39/TAB.15 SOLUBILITY OF HELIUM IN LIQUID DIOXYGEN DIFLUORIDE, PAGE 49

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AVIATORS BREATHING OXYGEN FROM AIRCRAFT CONVERTERS.
EVALUATION OF

-ABSTRACT-

TWO SAMPLES OF AVIATORS BREATHING OXYGEN WERE ANALYZED FOLLOWING AN ACCIDENT IN WHICH A PILOT WAS KILLED. THE LIQUID OXYGEN HAD BEEN OBTAINED FROM THE AIRCRAFT CARRIER USS BENNINGTON. THE SAMPLES WERE TAKEN FROM LOX CONVERTERS OF AIRCRAFT WHICH HAD OBTAINED LOX FROM THE BENNINGTON AT THE SAME TIME AS THE AIRCRAFT INVOLVED IN THE FATAL CRASH. THE SAMPLES CONTAINED CONTAMINANTS FAR IN EXCESS OF THE MAXIMUMS ALLOWED UNDER SPECIFICATIONS. PILOT COMPLAINTS OF BAD ODORS, HEADACHES, NAUSEA, AND LOSS OF COORDINATION WERE ATTRIBUTED TO THE OXYGEN SUPPLY. IT IS SUGGESTED THAT THE TOXIC EFFECTS OF THE CONTAMINANTS MIGHT BE ENHANCED WHEN BREATHING PURE OXYGEN. IN ADDITION, ONE SAMPLE CONTAINED ACETYLENE IN EXCESS OF ITS SOLUBILITY IN LOX, CONSTITUTING AN EXPLOSIVE HAZARD. THE REPORT RECOMMENDS THAT MEANS OF MONITORING CONTAMINANT LEVELS IN LOX BE PROVIDED TO AIRCRAFT CARRIERS AND ALL LAND-BASED PLANTS WHICH DO NOT HAVE SUCH INSTRUMENTATION. A SUGGESTED INSTRUMENT IS A GAS CHROMATOGRAPH SUCH AS THE NRL TOTAL HYDROCARBON ANALYZER.

-PERTINENT FIGURES-

TAB. ANALYTICAL DATA FOR OXYGEN SAMPLES FROM AIRCRAFT CONVERTERS, PAGE 5

-SOURCE INFORMATION-

CORPORATE SOURCE - NAVAL RESEARCH LAB., WASHINGTON, D.C.
REPORT NUMBER - 6186-176
OTHER INFORMATION - 0006 PAGES, 0001 FIGURES, 0000 TABLES, 0004 REFERENCES
DEVELOPMENT OF VULCANIZABLE ELASTOMERS SUITABLE FOR USE IN CONTACT WITH LIQUID OXYGEN. ANNUAL SUMMARY REPORT, JUNE 1967-MAY 1968

by

WARNER, D.A.

09/00/68

SECURITY CLASS: J/Unrestricted
ACCESS LEVEL: NTIS
REPORT CLASS: Incremental
ENTRY EVAL.: Acceptable

-ABSTRACT-

HOMOPOLYMERS HAVE BEEN PREPARED AND THEIR LOW TEMPERATURE TENSILE PROPERTIES STUDIED. INCREASING VALUES OF N WERE FOUND TO BRING ABOUT INCREASING ELONGATIONS AND DECREASING TENSILE STRENGTH AND TOUGHNESS. ATTEMPTS TO PREPARE COPOLYMERS WITH VINYLIDENE FLUORIDE WERE UNSUCCESSFUL. ATTEMPTS TO PREPARE CYCLOPOLYMERS OF PERFLUOROGlutARALDEHYDE, PERFLUOROGlycERYL FLUORIDE, AND PERFLUoro-3-Oxaheptadiene-1,6 WERE UNSUCCESSFUL. POLYANHYDRIDES OF FLUOROCARBON DICARBOXYLIC ACIDS WERE FOUND TO BE HYDROLYTICALLY UNSTABLE. POLYCONDENSATION OF PERFLUOROALDEHYDE HYDRATES WITH FLUOROCARBON DICARBOXYLIC ACIDS DID NOT PRODUCE THE EXPECTED LINEAR POLYESTERS. WORK WAS BEGUN ON THE PREPARATION OF ESTERS DERIVED FROM Oligomers OF HexaFluoropropylene Oxide.

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CORPORATE SOURCE - PENINSULAR CHEMRESEARCH, INC., GAINESVILLE, FLA.
SPONSOR - NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.
CONTRACT NUMBER - NAS8-5352
OTHER INFORMATION - 0063 PAGES, 0012 FIGURES, 0006 TABLES, 0016 REFERENCES
NEW DATA ON THE EXPLOSIVENESS OF LIQUID OXYGEN AND HYDRO-CARBONS (RUSSIAN)

by

GITTSEVICH, G.A.
BASYPOV, Z.B.
SAGAIDAK, V.J.

00/00/59

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Incremental Acceptable

-ABSTRACT-

EXPERIMENTS SHOWED THAT THE HEATING OF CYLINDER OIL, UNDER PRESSURE IN AIR, PRODUCES LOW-BOILING LIQUID AND GASEOUS HYDROCARBONS AND COKE, THE PRODUCTS OF THERMAL CRACKING. THESE PRODUCTS, MIXED WITH LIQUID OXYGEN, WERE TESTED FOR EXPLOSION SENSITIVITY, AND WERE FOUND TO BE MORE SENSITIVE TO IMPACT THAN NITROGLYCERINE. THE DATA SHOW THAT ACETYLENE SHOULD NOT BE CONSIDERED THE ONLY CAUSE OF EXPLOSIONS IN AIR SEPARATION EQUIPMENT. PRODUCTION OF SCAFFOLDING GASES IN RECIPROCATING COMPRESSORS, AND THEIR CONDENSATION WITH OXYGEN IN AIR SEPARATION EQUIPMENT, CAN EXPLAIN EXPLOSIONS IN CASES WHERE ACETYLENE AND LUBRICATING OIL WERE NOT FOUND. CLEANING OF THE PROCESS AIR, WITH REMOVAL OF ALL OILS AND OTHER HYDROCARBONS, CAN INSURE SAFE OPERATION OF AIR SEPARATION EQUIPMENT.

-PERTINENT FIGURES-

TAB. 1 COMPOSITION OF GASES OBTAINED BY THERMAL CRACKING OF OIL P-28 AT TEMPERATURES OF 200 AND 350 C, PAGE 14/TAB. 2 MINIMUM PRESSURE OF RUPTURE OF DIAPHRAGMS NECESSARY TO PRODUCE EXPLOSIONS IN VARIOUS MIXTURES, PAGE 15

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A STUDY OF TRACE IMPURITIES IN AVIATORS BREATHING OXYGEN

by

DREW, C. M.
SCHOWEN, R. L.
SMITH, S. R.

02/03/58

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted NTIS Incremental Acceptable

-ABSTRACT-

A STUDY OF AVIATORS BREATHING OXYGEN FROM PRESSURE AND LIQUID APPARATUS HAS BEEN CARRIED OUT TO DETERMINE THE IMPURITIES THAT ARE RESPONSIBLE FOR NAUSEA AND ANOXIATION REPORTED BY SOME PILOTS. AN ANALYTICAL METHOD USING GAS CHROMATOGRAPHY AND MASS SPECTROMETRY HAS BEEN USED TO DETERMINE THE IDENTITY AND CONCENTRATION OF THE CONTAMINANTS IN THE BREATHING OXYGEN. A POSSIBLE MECHANISM WHEREBY THESE CONTAMINANTS AFFECT THE PILOTS HAS BEEN PROPOSED AND RECOMMENDATIONS TO PURIFY THE BREATHING OXYGEN HAVE BEEN MADE. THE REPORT CONCLUDES WITH A NUMBER OF RECOMMENDATIONS MOSTLY CENTERING AROUND PURGING OF THE STORAGE TANKS, TRANSFER CARTS AND MOST ESPECIALLY THE CONVERTER TANKS IN THE AIRCRAFT. THE USE OF ABSORBENTS IN THE LOW PRESSURE FEED LINES IN THE AIRCRAFT IS ALSO RECOMMENDED.

-PERTINENT FIGURES-

FIG. 2 RUN NO. 501 LIQUID OXYGEN FROM CONVERTER, PAGE 13//FIG. 3 RUN NO. 503 STORAGE TANK NO. 1, PAGE 14//FIG. 4 RUN NO. 504 GAS FROM CONVERTER, PAGE 15//FIG. 7 RUN NO. 507 NEWLY REFILLED STORAGE TANK, PAGE 18//FIG. 8 RUN NO. 508 OXYGEN LIQUEFIED FROM CYLINDER, PAGE 19//TAB. 1 ANALYSIS OF OXYGEN SAMPLES, PAGES 24-26

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CORPORATE SOURCE -
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REPORT NUMBER -
NAVORD-R-5309//NOTS-1887
OTHER INFORMATION -
0026 PAGES, 0012 FIGURES, 0001 TABLES, 0006 REFERENCES
SURVEY OF CONTAMINATION IN ROCKET PROPULSION FLUID SYSTEMS

by

TELLIER, G.F.
LEWELLEN, J.W.
SIANDKE, H.

11/00/67

ABSTRACT

THIS REPORT PRESENTS THE PHASE I SURVEY RESULTS OF A PROGRAM TO GENERATE DESIGN CRITERIA FOR VALVE POPPETS AND SEATS CAPABLE OF SEALING RELIABLY IN THE CONTAMINATION ENVIRONMENT PRESENT IN ROCKET PROPULSION FLUID SYSTEMS. THE PURPOSE OF THE SURVEY WAS TO QUANTITATIVELY AND QUALITATIVELY DESCRIBE CONTAMINANTS (PRIMARILY PARTICULATES) OCCURRING IN THESE SYSTEMS. A COMPREHENSIVE LITERATURE SEARCH YIELDED CONSIDERABLE GENERALIZED INFORMATION ON CONTAMINATION DESCRIPTION WITH RESPECT TO TYPES, SOURCES, AND CONTROL. ADDITIONALLY, EXTENSIVE LITERATURE ON PARTICLE SIZE ANALYSIS AND GRAPHICAL DISPLAY WAS OBTAINED. THESE TWO CATEGORIES OF INFORMATION ARE SUMMARIZED AND A SUBJECT CATEGORIZED BIBLIOGRAPHY OF 209 ANNOTATED REFERENCES IS PRESENTED. A SURVEY OF ORGANIZATIONS ASSOCIATED WITH LIQUID ROCKET PROPULSION WAS PERFORMED FROM WHICH NUMEROUS SPECIFICATIONS AND TYPICAL CONTAMINATION DATA FOR A VARIETY OF FLUIDS, CONDITIONS, AND LOCATIONS WERE OBTAINED. THESE DATA, AS COMPILED AND TABULARLY PRESENTED, REPRESENT A WIDE SPECTRUM OF FLUID SYSTEM CONTAMINATION. THEY DO NOT, HOWEVER, SPECIFICALLY DEFINE CONTAMINATION IN OPERATING LIQUID ROCKET SYSTEMS. THIS RESULTS FROM EXTREME DIFFICULTIES IN OBTAINING REPRESENTATIVE SAMPLES AND MAKING ACCURATE MEASUREMENTS. THE REPORT REALLY IS A SURVEY, BUT IT DOES GIVE VARIOUS CLEANLINESS CRITERIA AND STANDARDS AS WELL AS CONTAMINATION DATA.

-PERTINENT FIGURES-

FIG. B-6 PARTICLE COUNT LIMITS FOR SPACE ENGINES PER ROCKETDYNE SPECIFICATION RA0615-003, PAGE 191//FIG. B-10 PARTICLE COUNT LIMITS FOR APOLLO SPACECRAFT DELIVERED PROPELLANTS PER NASA MSC-SPEC-2-6, PAGE 195//FIG. B-11 PARTICLE COUNT LIMITS AND DATA FOR APOLLO - SATURN, LM-RCS FROM NASA, KSC, PAGE 196//FIG. B-12 PARTICLE COUNT DATA FOR APOLLO - SATURN LM-RCS FROM NASA, KSC, PAGE 197//FIG. B-13 PARTICLE COUNT LIMITS AND DATA FOR APOLLO - SERVICE PROPULSION SYSTEM, PAGE 198//FIG. B-18 PARTICLE COUNT LIMITS AND DATA FOR F-1 ENGINE GIMBAL SYSTEM, PAGE 203

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CORPORATE SOURCE - POCKETDYNE, CAMLOGA PARK, CALIF.
REPORT NUMBER - X68-16850//AFRPL-TR-67-290//AD-829701
SPONSOR - AIR FORCE ROCKET PROPULSION LAB., EDWARDS AFB, CALIF.
CONTRACT NUMBER - CONTRACT F34611-67-C-0085
OTHER INFORMATION - 0237 PAGES, 0026 FIGURES, 0000 TABLES, 0210 REFERENCES
PROCESS FOR DEMETHANIZATION OF LIQUID OXYGEN

by

SAVAGE, D.W.

08/03/71

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Summary Acceptable

-ABSTRACT-

THE DISCLOSURE IS DIRECTED TO AN IMPROVED PROCESS FOR THE REMOVAL OF METHANE FROM A MIXTURE OF METHANE AND OXYGEN BY THE USE OF AN X-TYPE ZEOLITE CATALYST. THE USE OF SILVER AND CALCIUM CATION-EXCHANGED FORMS OF SYNTHETIC X ZEOLITES RESULT IN A MUCH HIGHER CAPACITY FOR METHANE REMOVAL THAN WAS HERETOFORE POSSIBLE UNDER THE PRIOR ART.

-SOURCE INFORMATION-

CORPORATE SOURCE - ESSO RESEARCH AND ENGINEERING CO., LINDEN, N.J.
REPORT NUMBER - U.S. PAT 3,597,169
OTHER INFORMATION - 0003 PAGES, 0000 FIGURES, 0002 TABLES, 0002 REFERENCES
EVALUATION OF USED LOX PUMP OIL (NU-TROL, MARK II), NU-CHEM INDUSTRIES, SHARPE'S, FLA.

by

WALTERS, G.L.

05/18/71

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U/Other Govt./Contr. Incremental Acceptable

-ABSTRACT-

THIS REPORT PRESENTS RESULTS OF AN EXAMINATION OF SIX SAMPLES OF USED LOX PUMP OIL. THE TESTS SHOWED NO BREAKDOWN OF CONSTITUENTS TO FORM FREE ACID, BUT THERE WERE AGGREGATES OF TETFLON PARTICLES SUGGESTING PRELIMINARY CHANGES. SOME OF THE OIL SHOWED LARGE AMOUNTS OF AGGREGATION FOR SHORT RUNNING TIMES, AND IT IS SUGGESTED THAT THE ALUMINUM PUMP HOUSING IS AIDING THE PROCESS. IT IS NOTED THAT THIS OIL HAS BEEN FOUND TO DETONATE WITH ALUMINUM UNDER SHEARING CONDITIONS. RESULTS OF ANALYSIS OF WEAR METALS IN THE OILS AND OF 4-BALL WEAR TESTS ARE ALSO PRESENTED.

-PERTINENT FIGURES-

TAB. 1 WEAR METAL ANALYSIS, PAGE 3/TAB. 2 4-BALL WEAR TEST RESULTS, PAGE 4

-SOURCE INFORMATION-

CORPORATE SOURCE - NATIONAL AERONAUTICS AND SPACE ADMINISTRATION. JOHN F. KENNEDY SPACE CENTER, COCOA BEACH, FLA.

REPORT NUMBER - AD-893511

OTHER INFORMATION - 0005 PAGES, 0000 FIGURES, 0002 TABLES, 0000 REFERENCES
THE DETERMINATION OF HYDROCARBON TRACES IN ATMOSPHERIC AIR AND LIQUID OXYGEN

by

THEER, J.

02/27/63

-ABSTRACT-

FOR A LONG TIME A RAPID METHOD OF DETERMINING TRACES OF HYDROCARBONS IN THE AIR SUCKED INTO AND THE LIQUID OXYGEN PRODUCT OF AIR SEPARATION PLANTS HAS BEEN SOUGHT. THIS IS NEEDED TO AVOID DANGERS OF EXPLOSIONS DUE TO THE ACCUMULATION OF HYDROCARBONS ESPECIALLY ACETYLENE. THIS PAPER DESCRIBES A GAS CHROMATOGRAPH WITH A MICROFLAME IONIZATION DETECTOR. A 10 ML SAMPLE CAN BE PROCESSED IN 5 MINUTES WITH A SENSITIVITY OF 5 PARTS PER BILLION AND IN 15 MINUTES A SENSITIVITY OF 10 PARTS PER BILLION CAN BE ACHIEVED. THE SAMPLER AND INSTRUMENT HAVE BEEN TESTED IN CONTINUOUS OPERATION.

-PERTINENT FIGURES-

TAB.P.6 HYDROCARBON CONTENT OF ATMOSPHERIC AIR FROM VARIOUS REGIONS OF GERMANY DEMOCRATIC REPUBLIC//FIG.3 HYDROCARBON CHROMATOGRAM FOR LIQUID OXYGEN, PAGE 7//FIG.4 CONCENTRATION APPARATUS FOR HYDROCARBONS FROM ATMOSPHERIC AIR, PAGE 8//FIG.5 HYDROCARBON CHROMATOGRAM FOR ATMOSPHERIC AIR, PAGE 7

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CORPORATE SOURCE - INSTITUTE FOR CHEMICAL AND REFRIGERATING EQUIPMENT, DRESDEN, EAST GERMANY

REPORT NUMBER - 86

ORIGINAL PAGE IS OF POOR QUALITY
EVAPORATION OF LIQUID OXYGEN LEADS TO CHANGES IN COMPOSITION BECAUSE OF DIFFERENCES BETWEEN THE VOLATILITY OF OXYGEN AND THE VOLATILITY OF IMPURITIES. AN EXPRESSION IS PRESENTED WHICH MAY BE USED TO ESTIMATE CHANGES IN COMPOSITION AS A CONSEQUENCE OF EVAPORATION DURING THE STORAGE OF LIQUID OXYGEN. THE SENSITIVITY OF FUEL-CELL SYSTEMS TO SUCH CHANGES IS DISCUSSED, AND SAMPLE CALCULATIONS ARE PRESENTED. SAMPLE CALCULATIONS ARE CARRIED OUT FOR PROPELLANT GRAYDE LIQUID OXYGEN, AND THE LIKELIHOOD AND EFFECT OF COMPOSITION CHANGES IN REFERENCE TO FUEL CELL SYSTEM OPERATION ARE DISCUSSED. THE SPECIFIC IMPURITIES INCLUDE CARBON DIOXIDE, METHANE, KRYPTON, NITROGEN AND ARGON. THE AUTHORS CONCLUDE THE OBLIGATIONS - THAT LIQUID WITHDRAWAL IS BEST AND THIS POINTS TO SUPERCRITICAL STORAGE.

-PERTINENT FIGURES-

TAB. I INITIAL LIQUID-OXYGEN IMPURITY LEVELS USED IN SAMPLE CALCULATIONS, PAGE 13/TAB. VIII EXPRESSIONS USED IN CASE 3 CALCULATIONS, PAGE 14/TAB. IX LIQUID-OXYGEN STORAG MODES, PAGE 15/FIG. 2 CONCENTRATION CHANGES IN PROPELLANT-GRAYDE LIQUID OXYGEN AS CONSEQUENCE OF EVAPORATION, PAGE 16/FIG. 3 CONCENTRATION CHANGES IN PROPELLANT-GRAYDE LIQUID OXYGEN AS CONSEQUENCE OF EVAPORATION (3 ATMOSPHERES PRESSURE), PAGE 17/FIG. 4 WITHDRAWAL PROFILE FOR CASE 3, PAGE 18

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CORPORATE SOURCE -
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION. LEWIS RESEARCH CENTER, CLEVELAND, OHIO

REPORT NUMBER -
N73-14056//NASA-TM-2686

OTHER INFORMATION -
0022 PAGES, 0006 FIGURES, 0009 TABLES, 0010 REFERENCES
-ABSTRACT-

The vast growth of industries producing cryogenic fluids with the attendant more complex processing systems is cited. The importance of accurate analysis for, and minimizing of contaminants in fuel and oxidizer process streams is stressed. Approximately 15 different accidents in hydrogen and oxygen systems, and air separation plants are briefly reported. A brief analysis for the possible causes of each is given. The various accidents cited were believed caused by brittle fracture of metals, oil or oil vapors mixed with oxygen enriched atmospheres, contaminants and contaminant concentrations in high pressure oxygen systems, smoking in oxygen enriched atmospheres, poor operating procedures, and valve actuation in high pressure oxygen systems. Each accident is only briefly explained along with the possible causes of each, but the more prevalent causes of accidents in oxygen and hydrogen systems are clearly pointed out.

-SOURCE INFORMATION-

CORPORATE SOURCE -
AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -
CRYOG. SAFETY CONF., FROC. OF, SESSION 1, 13-22, ALLENTOWN, PA., JUL 1959

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ORIGINIAL PAGE IS OF POOR QUALITY
A SELECTED GROUP OF ORGANIC COMPOUNDS WERE IMPACT TESTED WITH THE 
ADLA DROP-WEIGHT TESTER DURING THIS REPORT PERIOD. ATTEMPTS WERE 
MADE TO CORRELATE THE IMPACT SENSITIVITIES OF THESE COMPOUNDS WITH 
THEIR PHYSICAL PROPERTIES AND CHEMICAL STRUCTURE. IN SOME 
INSTANCES SUBGROUPS OF COMPOUNDS THAT ARE RELATED BY THEIR 
CHEMICAL STRUCTURE HAVE EXHIBITED SENSITIVITIES CORRELATING WITH 
THEIR FLASH POINTS. CHEMICAL STRUCTURE HAS ALSO BEEN SHOWN TO BE A 
FACTOR IN IMPACT SENSITIVITY. THE IMPACT SENSITIVITIES OF CUMENE, 
TOLUENE, AND T-ETHYLHEXENE ARE IN THE SAME ORDER AS THEIR 
REACTIVITIES TOWARD PEROXY RADICALS IN OXIDATION. A FEW OF THE 
COMPOUNDS THAT WERE IMPACT TESTED WERE IGNITED BY THE HOT-WIRE 
METHOD, AND MINIMUM IGNITION TEMPERATURES AND IGNITION-DELAY TIMES 
WERE MEASURED. THE HOT-WIRE SENSITIVITY OF COMPOUNDS WITHIN 
CERTAIN SUBGROUPS WERE AGAIN FOUND TO CORRELATE WITH THE EASE OF 
HOT-WIRE IGNITION. FURTHERMORE, HOT-WIRE DATA APPEAR TO AGREE WITH 
IMPACT DATA. TWO PRELIMINARY EXPERIMENTS LEADING TO THE USE OF 
HIGH-SPEED PHOTOGRAPHY FOR THE STUDY OF IMPACT-INDUCED IGNITION 
MECHANISMS WERE PERFORMED.

-PERTINENT FIGURES-

TAB.1 IMPACT SENSITIVITY VERSUS PHYSICAL PROPERTIES FOR PURE 
ORGANIC COMPOUNDS, PAGE 6/ TAB.2 COMPARISON OF IMPACT AND HOT-WIRE 
SENSITIVITY DATA, PAGE 7/ TAB.3 REACTION OF OXYGEN WITH ME(6)AL(2) 
IN CF(2)Cl(2), PAGE 14

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SPONSOR - National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

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II. REACTION CHARACTERISTICS OF ORGANIC COMPOUNDS WITH OXYGEN
FIRE AND EXPLOSIC N HAZARDS OF FLIGHT VEHICLE COMBUSTIBLES

by

LITCHFIELD, E. L.
PERLFE, H. E.

03/00/65

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REPORT CLASS Incremental
ENTRY EVAL. Good/Excel.

-ABSTRACT-

SEVERE EXPLOSION HAZARDS COULD RESULT FROM A MASSIVE SPILL OF LO-HYDROGOLIC FUEL AND OXIDIZER OF A MISSILE PROPULSION SYSTEM. THIS PROBLEM WOULD BE ESPECIALLY SEVERE WITH THE HIGH-ENERGY SYSTEMS WHERE ONE OR BOTH OF THE PROPELLANT COMPONENTS ARE CRYOGENS. THE SENSITIVITY OF TWO SUCH SYSTEMS, LIQUID HYDROGEN PLUS SOLID OXYGEN PLUS DILUENT AND LIQUID OXYGEN PLUS SOLID HYDROCARBON PLUS DILUENT, HAS BEEN INVESTIGATED Employing a PROJECTILE IMPACT TO DETERMINE THE SHOCK REQUIRED TO DETONATE THESE MIXTURES. WITH NO DILUENT, EACH EXPLOSIVE SYSTEM IS INITIATED BY A SHOCK STIMULUS OF 1.0 TO 2.5 KBAR. THE EXPLOSIVE YIELDS ARE SUCH THAT 1-LB CRYOGENIC MIXTURE IS EQUIVALENT TO 0.6 TO 2.0 LB TNT. SODIUM CHLORIDE, NITROGEN, AND METHYL CHLORIDE HAD INERT DESSENSITIZING EFFECTS UPON THE LIQUID HYDROGEN MIXTURES BUT DID NOT REDUCE THE EXPLOSIVE YIELD. SODIUM CHLORIDE AND NITROGEN DESSENSITIZED THE LIQUID OXYGEN SYSTEM. SODIUM CHLORIDE OR WATER REDUCED THE EXPLOSIVE YIELD OF THIS SYSTEM. LARGE VOLUMES OF DETONABLE, GASEOUS HYDROGEN-OXYGEN MIXTURES WOULD RESULT FROM A MASSIVE SPILL OF LIQUID HYDROGEN-LIQUID OXYGEN. INHIBITION OF DETONATION INITIATION BY DRY POWER PARTICLE ADDITIVES WAS INVESTIGATED. THE POWDER ADDITIVES PRODUCED INSIGNIFICANT INHIBITION IN COMPARISON TO THAT PRODUCED BY GASEOUS DILUENTS.

FLAMMABILITY LIMIT DETERMINATIONS OF FOUR ADDITIONAL HALOGENATED HYDROCARBONS ARE INCLUDED IN A DISCUSSION OF THE CHARACTERISTICS OF 10 SUCH COMPOUNDS. MOST OF THE COMPOUNDS WERE FLAMMABLE IN OXYGEN ATMOSPHERES AT TEMPERATURES BELOW 200 DEGREES F, THEIR COMBUSTION PRODUCTS INCLUDED TOXIC HALOGENS OR HALOGEN HLALIDES.

-PERTINENT FIGURES-

IG. 1 TYPICAL PRESSURE HISTORY RECORD OBTAINED DURING COMBUSTION OF 50 VOLUME PERCENT CF(2)Br(2) IN AN OXYGEN ATMOSPHERE IN A 1-FOOT DIAMETER SPHERE, PAGE 23/FIG. 2 APPARATUS USED TO MEASURE MINIMUM EXPLOSION PressURES DURING COMBUSTION OF CONFINED GAS MIXTURES, PAGE 24/TAB. 1 PROJECTILE IMPACT SENSITIVITY OF LH(2) PLUS DILUENT, PAGE 5/TAB. 2 PROJECTILE IMPACT SENSITIVITY OF LO(2) PLUS SOLID HYDROCARBON PLUS DILUENT, PAGE 7/TAB.
HALOGENATED HYDROCARBONS IN VARIOUS OXIDANT ATMOSPHERES AT ATMOSPHERIC PRESSURE IN A 250-CC GLASS VESSEL, PAGE 14 // TAB. 4
YIELD OF CARBON DIOXIDE IN AN OXYGEN ATMOSPHERE AT VARIOUS TEMPERATURES FOR A REACTION PERIOD OF ONE MINUTE IN A GLASS VESSEL, PAGE 16 // TAB. 5
LIMITS OF FLAMMABILITY OF VARIOUS HALOGENATED HYDROCARBONS (VOLUME PERCENT) IN GLASS AND STAINLESS STEEL, PAGE 16 // TAB. 6
LIMITS OF FLAMMABILITY OF VARIOUS HALOGENATED HYDROCARBONS (VOLUME PERCENT) IN AIR, OXYGEN AND NITROGEN TETROXIDE ATMOSPHERES IN GLASS VESSELS, PAGE 17 // TAB. 7
MAXIMUM PRESSURES, RATES OF PRESSURE RISE AND BROMINE CONCENTRATIONS DEVELOPED DURING COMBUSTION OF FIVE HALOGENATED HYDROCARBONS IN OXYGEN AND AIR ATMOSPHERES, PAGE 18.

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CORPORATE SOURCE - BUREAU OF MINES, PITTSBURGH, PA. EXPLOSIVES RESEARCH CENTER
REPORT NUMBER - N-66-17589/AFAPI-TR-65-28/AD-614694
SPONSOR - AIR FORCE AERO-PROPULSION LAB., WRIGHT-PATTERSON AFB, OHIO
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SAFETY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN

by

KELLER, E. E.

02/21/57

-ABSTRACT-

TEST, METHOD AND APPARATUS AND TEST RESULTS OF IMPACT SENSITIVITY OF VARIOUS MATERIALS IN LIQUID OXYGEN ARE PRESENTED. ALSO PRESENTED ARE AN ABSTRACT OF A PAPER ON BEHAVIOR OF LIQUID OXYGEN AND A LITERATURE SURVEY OF REACTIONS OF ORGANIC MATERIALS WITH LIQUID OXYGEN. CONCLUSION IS THAT MOST REDUCING AGENTS AND HYDROCARBONS IN CONTACT WITH LIQUID OXYGEN CONSTITUTE A POTENTIAL EXPLOSIVE HAZARD.

-PERTINENT FIGURES-

DRAWING IMPACT TESTER PAGES 17-26 // TABLE 1 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGES 6-10 // TABLE 2 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGE 11 // TABLE 3 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGE 12 // TABLE 4 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGE 12 (A)

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-SOURCE INFORMATION-

CORPORATE SOURCE -
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LIQUID OXYGEN DISPOSAL VESSEL EXPLOSION

by

BOYNE, W. J.

00/00/66

-ABSTRACT-

An explosion occurred in the liquid oxygen disposal vessel of an air separation plant that was designed and operated in such a way as to avoid any hazardous hydrocarbon concentrations. A bleed of liquid oxygen from the reboiler prevents a build-up of impurity concentrations in the liquifier. The transfer of impurities from a hydrocarbon contaminated gaseous nitrogen stream, existing from a rich liquid filter undergoing regeneration, to liquid phase purge oxygen while they flowed concurrently through the purge piping to the disposal tank substantially increased to a hydrocarbon level in the liquid to a hazardous condition which then was presumably ignited and detonated by a steam heated vaporization tray in the disposal unit. Modifications prevent the regeneration gas from intimately contacting the purge liquid oxygen, thereby inhibiting any transfer and buildup of contaminants in the purge stream.

-PERTINENT FIGURES-

FIG. 1 SIMPLIFIED PROCESS FLOW DIAGRAM, PAGE 7
FIG. 2 ENGINEERING SKETCH OF THE LIQUID OXYGEN DISPOSAL VESSEL, PAGE 8
FIG. 6 TYPICAL CONCENTRATION PROFILE FOR ACETYLENE, PAGE 10
TAB. 1 HYDROCARBON ANALYSIS FOR PURGE LIQUID OXYGEN, PAGE 10

-SOURCE INFORMATION-

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ORIGINAL PAGE IS IN POOR QUALITY
THE RELATIONSHIP OF PHYSICAL, CHEMICAL AND THERMODYNAMIC
PROPERTIES TO SAFETY

by

MCKINLEY, C.

11/17/70

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Summary Good/Excel.

-ABSTRACT-

SEVERAL TESTS WERE CONDUCTED TO OBTAIN EXPERIMENTAL DATA ON THE EXPLOSIVE AND DETONATION CHARACTERISTICS OF HYDROCARBON - LIQUID OXYGEN MIXTURES. A LIQUID MIXTURE OF 25 MOLE PERCENT METHANE AND 75 MOLE PERCENT OXYGEN AT 76 K WAS DETONATED WITH A DYNAMITE CAP TO DETERMINE IF AN EXPLOSION COULD RESULT FROM CONDENSATION AND FRACTIONIZATION OF HYDROCARBONS AND AIR ON THE OUTSIDE OF A COLD PIPE. ANOTHER TEST WAS CONDUCTED TO DETERMINE THE LOWER EXPLOSIVE LIMITS OF A 50 - 50 METHANE - ETHANE MIXTURE IN LIQUID OXYGEN. IT WAS DETERMINED THAT THE LOWER EXPLOSIVE LIMIT FOR THE MIXTURE WAS ABOUT 6.2 MOLE PERCENT. THE POSSIBILITY OF A RELATIONSHIP BETWEEN THE EXPLOSIVE LIMITS OF GAS PHASE AND LIQUID PHASE CH(4) - O(2) MIXTURES WAS DISCUSSED. AN EXPERIMENTAL TEST WAS CONDUCTED TO DETERMINE THE LOWER AND UPPER EXPLOSION LIMITS OF METHANE IN LIQUID OXYGEN AT -320 DEGREES F, AND THE TEST RESULTS INDICATED THAT THESE LIMITS ARE 10.5 AND 59 MOLE PERCENT METHANE IN LIQUID OXYGEN. A TEST WAS CONDUCTED TO DETERMINE IF CONCENTRATED HYDROCARBON CONTAMINATION IN SILICA GEL ADSORBENT COULD DETONATE IN LIQUID OXYGEN. MIXTURES OF 4 AND 5 MOLE PERCENT ETHANE IN LIQUID OXYGEN WERE DETONATED AT -320 DEGREES F. VARIOUS ASPECTS OF THE EXPERIMENTAL TESTS WERE DISCUSSED.

-PERTINENT FIGURES-

TAB. 1 GAS PHASE FLAMMABLE LIMITS - CARBON ATOM APPROXIMATION PAGE 81

-SOURCE INFORMATION-

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PUBLISHER - AIR PRODUCTS, INC., ALLENTOWN, PA.
OTHER INFORMATION -
SAFETY ASPECTS OF RECONSTRUCTED ICI TONNAGE OXYGEN PLANT

by

MATTHEWS, W.D.

OWEN, S.G.

00/00/63

-ABSTRACT-


-PERTINENT FIGURES-

FIG. 9 FINAL DESIGN OF LOX JOINT, PAGE 9

FIG. 10 STRESS VARIATION IN LOX FLANGE BOLTS DURING COOLING CYCLES, PAGE 10

-SOURCE INFORMATION-

CORPORATE SOURCE - IMPERIAL CHEMICAL INDUSTRIES, LTD., BILLINGHAM/ENGLAND

JOURNAL PROCEEDINGS - SAFETY IN AIR AND AMMONIA PLANTS, VOL 5, 1-15 (PROC. OF A SYMP. AT DENVER, COLO, AUG 26-9, 1962)

PUBLISHER - AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, NEW YORK

OTHER INFORMATION -
THE ROLE OF AIR CONTAMINANTS IN FORMULATING OXYGEN PLANT SAFETY PRINCIPLES

by

MCKINLEY, C.
MUEMELDERGER, F.

03/00/57

SUMMARY

This article traces the history of the development of air separation plants relative to safety problems due to contaminants that react with oxygen. A table of about 25 common contaminants in an air plant shows the normal boiling and freezing points. Another table showing the solubility limits of most of these contaminants is also given. The explosion characteristics and flammability limits of several of the contaminants in liquid oxygen are discussed. Methods of contamination level control or removal are mentioned. Also discussed are methods of preventing explosions. Experimental explosion test data is given. Continuous hydrocarbon analysis is recommended.

-PERTINENT FIGURES-

Fig. 1 Methane-Liquid Oxygen Phase System, Page 11//Fig. 2 Ethane-Liquid Oxygen Phase System, Page 11//Fig. 3 Explosion Testing Apparatus, Page 17//Fig. 4 Schematic Diagram of Continuous Total Hydrocarbon Analyzer, Page 15//Fig. 6 Sample Strip Chart from Analyzer Showing Operating Cycle, Page 17//Tab. 1 Properties of Some Air Contaminants, Page 11//Tab. 2 Solubility of Various Materials in Liquid Oxygen, Page 11//Tab. 3 Gas Phase Flammable Limit - Carbon Atom Approximation, Page 15//Tab. 4 Flammability and Detonability Limits - Gases, Page 15//Tab. 5 Experimental Explosion Test Data, Page 14//Tab. 6 Type of Contaminant Analyses, Page 17

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by

MILL,T.
CHAMBERLAIN,D.L.
STRINGHAM,R.S.
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05/15/69

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-ABSTRACT-

THE IMPACT SENSITIVITY OF ORGANIC COMPOUNDS IN LIQUID OXYGEN WAS DETERMINED TO DEFINE THE IGNITION MECHANISM IN LHX AND TO ENSURE THE RELATIONSHIP BETWEEN SENSITIVITY AND CHEMICAL AND PHYSICAL PROPERTIES. A MODIFIED AEMA DROP-WEIGHT TESTER WAS USED TO MEASURE IMPACT SENSITIVITY. FOR 18 OF THE 24 COMPOUNDS TESTED, A SENSITIVE CORRELATION WAS FOUND TO EXIST BETWEEN THE RELATIVE SENSITIVITY AND FLASH POINT. FIVE OTHER COMPOUNDS, REACTIVITY IN OXIDATION, THE RELATIVE REACTIVITY OF T-BUTOXY AND T-BUTYL ROXY RADICALS TOWARD A VARIETY OF ORGANIC COMPOUNDS AT 50, 100, AND 150 DEGREES C WAS EXAMINED. A GOOD CORRELATION WAS FOUND BETWEEN RELATIVE REACTIVITY OF BOTH RADICALS TOWARD FIVE DIOXANES. THE CORRELATION FOR FOUR ALIPHATIC DERIVATIVES WAS GOOD. NO CORRELATION WAS FOUND BETWEEN REACTIVITY IN OXIDATION AND IMPACT SENSITIVITY FOR THE ALIPHATIC COMPOUNDS TESTED.

-PERTINENT FIGURES-

G.1 HOT-WIRE IGNITION APPARATUS PAGE 14/FIG.2 HOT-WIRE PARATUS SCHEMATIC DIAGRAM PAGE 15/FIG.3 SAMPLE SUPPORT PARATUS PAGE 17/FIG.4A NON-IGNITION (BLANK) PAGE 20/FIG.4B IGNITION OF BENZYL ALCOHOL (NO. 1) PAGE 20/FIG.4C IGNITION OF NITROBENZYL ALCOHOL (NO. 2) PAGE 20/FIG.5 PLATINUM WIRE VS BRIDGE TIP PAGE 21/FIG.6 DROP-WEIGHT TESTER MODIFIED FOR HIGH-SPEED PHOTOGRAPHY PAGE 24/FIG.7 CROSS SECTION OF ANVIL ASSEMBLY PAGE 27/FIG.8 LEYAN ANVIL-CUP PAGE 27/FIG.9 STILL PHOTOGRAPH OF ACTION FLASH PAGE 28/FIG.10 TRIGGERED TRACES OF REACTION FLASH GE 30/FIG.10A IMPACT TRIGGERED TRACES PAGE 30/FIG.10A LIGHT IGERED TRACE PAGE 30/FIG.11 IMPACT IGNITION AND PROPAGATION OF NITROBENZYL ALCOHOL IN LIQUID OXYGEN PAGE 32/FIG.12 APPLIATUS FOR W-TEMPERATURE OXIDATION OF ME(6)AL(2) PAGE 49/FIG.13 NAR}

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ABSTRACT

THIS REPORT PRESENTS THE RESULTS OF THE PHYSICAL, METALLURGICAL, CHEMICAL, AND THERMODYNAMIC SURVEYS THAT HAVE BEEN MADE ON THE HIGH-PRESSURE TANK AND PLUMBING SYSTEMS OF THE APOLLO SPACECRAFT. THESE SYSTEMS COMPRIS THE PRESSURIZED OXYGEN, HYDROGEN, NITROGEN, PROPELLANT, AND HELIUM TANKS AND RELATED PLUMBING OF THE COMMAND, SERVICE, AND LUNAR MODULES. THE PURPOSES OF THE SURVEYS ARE TO LEAD SUPPORT TO THE APOLLO 13 INVESTIGATION, TO PROVIDE REVIEW AND TO EXTEND KNOWLEDGE OF SPACECRAFT PRESSURE SYSTEMS, AND TO CONTRIBUTE TO THE SAFETY OF FUTURE MANNED SPACE FLIGHTS. TO ACHIEVE THESE OBJECTIVES, DESCRIPTIVE DATA FOR ALL TANKS WERE COLLECTED, A METALLURGICAL SURVEY AND A COMPREHENSIVE PHYSICAL CHEMICAL SURVEY OF ALL SYSTEMS WERE MADE, AND SOME DETAILED THERMODYNAMICAL CALCULATIONS WERE PERFORMED. THE OVERALL DESCRIPTIVE SURVEY OF THE HIGH-PRESSURE TANKS USED ON THE APOLLO SPACECRAFT SYSTEMS, INCLUDING A REVIEW OF THE METALLURGY INVOLVED IN THEIR CONSTRUCTION, POINTED TO (1) THE IMPORTANCE OF A CRITICAL EXAMINATION OF ANY INCOMPATIBILITIES IN MATERIAL SELECTIONS AND (2) THE NEED FOR PHYSICAL CHEMISTRY AND CATALYSIS STUDIES OF THE REACTION PROCESSES INVOLVED IN HIGH-PRESSURE FLUID SYSTEMS. THE RESULT IS A CRITICAL ASSESSMENT OF THE PHYSICAL AND CHEMICAL PROCESSES THAT CAN OCCUR IN HIGH-PRESSURE FLUIDS AND AN ASSESSMENT OF THE HAZARDS AND POSSIBLE FAILURE MECHANISMS ASSOCIATED WITH CONTAINMENT OF CRYOGENIC MATERIALS. FINDINGS BASED ON THESE SURVEYS ARE TABULATED IN THE REPORT. THE REPORT IS EXCELLENT.

-PERTINENT FIGURES-

FIG. D-1 NUMBER 2 OXYGEN TANK PRESSURE HISTORY, PAGE 90/FIG. D-2 NUMBER 2 OXYGEN TANK TEMPERATURE HISTORY, PAGE 91/FIG. D-3 NUMBER 2 OXYGEN TANK ENERGY HISTORY, PAGE 92/FIG. D-9 ENERGY-ADDITION RATE HISTORIES, PAGE 98/FIG. 1-1 APOLLO PRESSURE VESSELS, PAGES 7-11/TAB. A-2 ANALYTICAL CRITERIA, PRESSURE, TEMPERATURE, FLOW, AND ELECTRICAL DATA, PAGES 12-14

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ORIGINAL PAGE IS OF POOR QUALITY
INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS
WITH LIQUID OXYGEN QUARTERLY REPT. NO. 2, JUL 23 - OCT 22, 1963

by

HILL, T.
CHAMBERLAIN, D.L.
STRINGHAM, R.S.
KIRSHEH, N.A.
IRWIN, K.C.

11/12/63

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted NTIS Incremental Acceptable

-ABSTRACT-

THIS PROGRAM HAS TWO MAJOR ASPECTS. (A) STUDY OF THOSE FACTORS AFFECTING THE IGNITION PROCESSES AND (B) STUDY OF THE CHEMICAL MECHANISMS OF FREE RADICAL FORMATION AND OXIDATION OF SELECTED ORGANIC MATERIALS. DURING THIS QUARTER, MOST OF THE EFFORT ON THE FIRST ASPECT OF THE PROGRAM WAS DEVOTED TO MEASUREMENTS OF IMPACT SENSITIVITY OF SEVERAL HOMOLOGOUS SERIES OF ORGANIC COMPOUNDS INCLUDING AROMATICS, NORMAL AND CYCLOALKANES, AND ISOPROPYL DERIVATIVES. SOME CORRELATIONS BETWEEN IMPACT SENSITIVITY AND PHYSICAL PROPERTIES HAVE BEEN NOTED. CALIBRATION OF THE HOT-WIRE APPARATUS HAS BEEN COMPLETED. IN THE SECOND PART OF THE PROGRAM, WORK HAS CONTINUED ON THE REACTION OF OXYGEN WITH TRIMETHYALUMINUM AT -140 DEGREES. KINETIC DATA INDICATE THE REACTION IS BIMOLECULAR AND EXCEPTIONALLY FAST. REACTIONS OF T-BUTOXY RADICAL WITH BENZYL AND ISOPROPYL COMPOUNDS REVEALED SOME SURPRISING REACTIVITY RELATIONSHIPS. BUT NO CLEAR EVIDENCE WAS OBTAINED FOR CORRELATIONS WITH IMPACT SENSITIVITY MEASUREMENTS.

-PERTINENT FIGURES-

FIG.1 SAMPLE SUPPORT APPARATUS, PAGE 9//FIG.2 BRIDGE OUTPUT VERSUS PLATINUM WIRE TEMPERATURE, PAGE 12//FIG.3 HOT WIRE IGNITION OF BENZYL ALCOHOL, PAGE 14//TAB.1 INITIAL SCREENING TESTS FOR PURE ORGANIC COMPOUNDS, PAGE 5//TAB.2 IMPACT TESTS OF FOUR PURE ORGANIC COMPOUNDS, PAGE 7//TAB.3 FIXED TEMPERATURES FOR HOT-WIRE CALIBRATION, PAGE 11

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-SOURCE INFORMATION-

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SPONSOR - NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.
CONTRACT NUMBER - CONTRACT NASA-21316
OTHER INFORMATION - 0025 PAGES, 0005 FIGURES, 0006 TABLES, 0008 REFERENCES
OXYGEN PLANT SAFETY

by

KAPWE, E.

04/00/57

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J/Unrestricted Unlimited Summary Acceptable

-ABSTRACT-

THIS SHORT ARTICLE DISCUSSES THE RELATIVE SAFETY AND YET OCCASIONAL EXPLOSIONS THAT OCCUR IN LIQUID OXYGEN GENERATING PLANTS. EXPERIMENTS WITH ACETYLENE SHOW THE LONGER AS WELL AS SAFER OPERATING LIMITS FOR THIS MATERIAL OZONE IS ALSO DISCUSSED AND EXPLOSIVE LIMITS GIVEN (ROUGHLY 18 PERCENT BY VOLUME IN LIQUID OXYGEN) FOR LIX CONTAINING HYDROCARBON IMPURITIES, GREAT CARE MUST BE TAKEN IN VAPORIZING THE LIQUID.

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-PERTINENT FIGURES-
TAB. 1 ACETYLENE CONTAMINANT LEVELS IN PLANT OPERATION, PAGE 11/TAB. 2 CONTAMINANTS ON THE RICH-LIQUID AND LIQUID OXYGEN FILTERS IN NO. 2 AND NO. 3 PLANTS, PAGE 11

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OTHER INFORMATION - 1004 PAGES, 0005 FIGURES, 0002 TABLES, 0000 REFERENCES

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DISCUSSION OF ENERGY RELEASE IN A LIQUID OXYGEN PUMP

by

EALL, W. L.

00/00/63

-ABSTRACT-

THIS REPORT DISCUSSES A LIQUID OXYGEN PUMP INCIDENT THAT RESULTED IN CONSIDERABLE DAMAGE TO THE PUMP AND SHUTDOWN OF AN AIR SEPARATION PLANT. THE PUMP DESCRIBED IS A 10-STAGE VERTICAL PUMP WHICH TAKES LIQUID OXYGEN FROM THE REBOILER OVERFLOW AND DISCHARGES TO THE MAIN AIR EXCHANGERS WHERE THE LIQUID IS VAPORIZED AND SENT TO STORAGE OR TRANSMISSION LINES. FOR RELIABILITY, TWO PUMPS ARE INSTALLED (ONE AS A SPARE) IN A SINGLE INSULATED PUMP BOX, AND THE SPARE PUMP IS KEPT ON COLD STAND-BY. INVESTIGATION REVEALED THAT THE COLD STAND-BY PROCEDURE PROVIDED MEANS OF CONCENTRATING CONTAMINANTS IN THE PUMP, AND ALTERNATE NON-CONCENTRATING METHODS OF COOLING WERE STUDIED AS A RESULT.

-SOURCE INFORMATION-

CORPORATE SOURCE -
AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -
SAFETY IN AIR AND AMMONIA PLANTS, VOL 5, 41-2 (PROCEEDINGS OF A SYMP. AT DENVER, COLO., AUG 26-9, 1962)

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EXPLOSIONS CAUSED BY LIQUID OXYGEN

by

WEPER, U.

00/00/63

-ABSTRACT-

CHEMISTS HAVE KNOWN FOR A LONG TIME THAT ALTHOUGH LIQUID OXYGEN ITSELF IS NON-FLAMMABLE AND NON-TOXIC, ITS HANDLING NEVERTHELESS PRESENTS SERIOUS RISKS AS ALL COMBUSTION IN THE PRESENCE OF OXYGEN IS MUCH QUICKER THAN IN THE AIR AND BECAUSE MIXTURES OF ORGANIC SUBSTANCES WITH LIQUID OXYGEN CAN EXPLODE. HANDLING OF OXYGEN IN LABORATORIES THEREFORE IS CARRIED OUT WITH EVERY RECOGNISED PRECAUTION AND ACCIDENTS ARE RARE. UNFORTUNATELY, IN RECENT TIMES, SOME SERIOUS EXPLOSIONS HAVE OCCURRED IN THE FEDERAL REPUBLIC OF GERMANY IN INDUSTRIES USING LIQUID OXYGEN ON A LARGE SCALE AND AT THE TIME OF TRANSPORTING THE LIQUID OXYGEN BY TANKER. THESE ACCIDENTS HAVE LED THE AUTHORITIES TO TAKE CERTAIN SPECIAL SAFETY MEASURES WHICH MAY BE OF INTEREST TO OTHERS CONCERNED WITH THIS BRANCH OF ACTIVITY. THE EXAMPLES AND SAFETY MEASURES CITED IN THIS ARTICLE ARE OF GENERALLY COMMON KNOWLEDGE TODAY, HOWEVER, AND IT IS THEREFORE OF MARGINAL INTEREST.

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OTHER INFORMATION -
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SAFETY ASPECTS IN THE DESIGN AND OPERATION OF OXYGEN SYSTEMS

by

REYNALD, C.H.

01/00/59

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-ABSTRACT-

This paper deals with the behavior and properties of oxygen as they apply to safety aspects in the design and operation of the oxygen transfer system of the Thor missile. The paper summarizes the findings of a study on the compatibility of materials with oxygen, lists the results of various tests performed to determine the resistance of materials and contaminants to ignition in an oxygen atmosphere, and reviews the observations from a field survey made among the organizations most actively engaged in the production and use of oxygen. The overall conclusion from this project is that oxygen is a potential explosive which should be handled with care. There are three basic elements required for combustion, one of which is oxygen. The other two are the combustible materials and the sources of energy needed to induce a reaction. Until we learn more about the first element, oxygen, it is necessary to control the other two. This can be done by reducing or eliminating the sources of energy throughout a system and by a cleaning and maintenance program aimed at the elimination and avoidance of contaminants.

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116
SURVEY OF ACCIDENTS AT THE AIR SEPARATION PLANTS

-ABSTRACT-

A LARGE NUMBER OF ACCIDENTS WHICH OCCURRED IN AIR SEPARATION PLANTS IN JAPAN AND ELSEWHERE ARE ANALYZED. CLAUDE-TYPE, LINDE-TYPE, AND FRANKEL-TYPE SEPARATION PLANTS ARE DISCUSSED. ACCIDENTS WERE CLASSIFIED INTO EXPLOSIONS, BURSTING ACCIDENTS AND ACCIDENTS IN WHICH HUMANS WERE INJURED OR KILLED. VARIOUS ACCIDENT MODES ARE ANALYZED, AND THE SUCCESS OF APPROPRIATE COUNTERMEASURES IS DESCRIBED. DATA ON ALL AIR SEPARATION PLANTS IN JAPAN ARE GIVEN. MANY SAFETY RECOMMENDATIONS ARE GIVEN THROUGHOUT THE REPORT.

-PERTINENT FIGURES-


-BIBLIOGRAPHY-


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JOURNAL PROCEEDINGS - J. AMMONIUM SULPHATE ENG. VOL 17, NO. 3, (1964) (TRANSL. BY SCIENTIFIC TRANSLATION SERVICE, DEC. 1970)
OTHER INFORMATION - 0122 PAGES, 0010 FIGURES, 0016 TABLES, 0013 REFERENCES
INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS WITH LIQUID OXYGEN, QUARTERLY REPORT NO. 3/ OCT 23, 1968 TO JAN 22, 1969

by

MILL, T.
CHAMBERLAIN, D.L.
STRINGHAM, R.S.
KIRSHEN, N.A.
IRWIN, N.C.

02/12/68

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-ABSTRACT-

A SELECTED GROUP OF ORGANIC COMPOUNDS WERE IMPACT TESTED WITH THE ABMA DROP-WEIGHT TESTER DURING THIS REPORT PERIOD. ATTEMPTS WERE MADE TO CORRELATE THE IMPACT SENSITIVITIES OF THESE COMPOUNDS WITH THEIR PHYSICAL PROPERTIES AND CHEMICAL STRUCTURE. IN SOME INSTANCES SUBGROUPS OF COMPOUNDS THAT ARE RELATED BY THEIR CHEMICAL STRUCTURE HAVE EXHIBITED SENSITIVITIES CORRELATING WITH THEIR FLASH POINTS. CHEMICAL STRUCTURE HAS ALSO BEEN SHOWN TO BE A FACTOR IN IMPACT SENSITIVITY. THE IMPACT SENSITIVITIES OF CUMENE, TOLUENE, AND T-BUTYL BENZENE ARE IN THE SAME ORDER AS THEIR REACTIVITIES TOWARD PEROXY RADICALS IN OXIDATION. A FEW OF THE COMPOUNDS THAT WERE IMPACT TESTED WERE IGTNITED BY THE HOT-WIRE METHOD, AND MINIMUM IGNITION TEMPERATURES AND IGNITION-DELAY TIMES WERE MEASURED. THE HOT-WIRE SENSITIVITY OF COMPOUNDS WITHIN CERTAIN SUBGROUPS WERE AGAIN FOUND TO CORRELATE WITH THE BASE OF HOT-WIRE IGNITION. FURTHERMORE, HOT-WIRE DATA APPEAR TO AGREE WITH IMPACT DATA. TWO PRELIMINARY EXPERIMENTS LEADING TO THE USE OF HIGH-SPEED PHOTOGRAPHY FOR THE STUDY OF IMPACT-INDUCED IGNITION MECHANISMS WERE PERFORMED.

-PERTINENT FIGURES-

TAB. 1 IMPACT SENSITIVITY VERSUS PHYSICAL PROPERTIES FOR PURE ORGANIC COMPOUNDS, PAGE 6/ TAB. 2 COMPARISON OF IMPACT AND HOT-WIRE SENSITIVITY DATA, PAGE 9/ TAB. 3 REACTION OF OXYGEN WITH ME(6)AL(2) IN CP(2)CL(2), PAGE 18

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PROPELLANT STATIC SEAL DEVELOPMENT IN PROJECT HERMES

by

JENKINS, T.C.
LOGAN, S.E.

11/09/54

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-ABSTRACT-

THIS REPORT REVIEWS THE ADVANCEMENTS MADE TOWARD BETTER PROPELLANT SEALING DEVICES DURING THE HERMES PROGRAM. IT DISCUSSES THE PROBLEMS WHICH WERE OVERCOME IN THE DESIGN OF COMPONENTS CARRYING LIQUID OXYGEN. IMPROVEMENTS ARE NOTED FOR TUBE JOINTS, AND DETONATION TESTS WITH VARIOUS ELASTOMERS ARE DISCUSSED.

-PERMANENT FIGURES-

FIG. 41 DETONATION TEST SCORE VERSUS FILLER FOR VARIOUS ELASTOMERS, PAGE 36 // FIG. 42 DETONATION TEST SCORE VERSUS HARDNESS FOR VARIOUS ELASTOMERS, PAGE

-SOURCE INFORMATION-

CORPORATE SOURCE -
GENERAL ELECTRIC CO., SCHENECTADY, N.Y. GUIDED MISSILES DEPT.

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SAFETY PRECAUTIONS WITH RESPECT TO HYDROCARBONS IN AIR FRACTIONATING APPARATUS (SCHUTZMAFSNAKEM GEGEN KOHLENWASSERSTOFFE IM LUFTTRENNER)

by

KAPWAE, E.  
11/00/60

SECURITY CLASS : ACCESS LEVEL : REPORT CLASS : ENTRY EVAL.

-ABSTRACT-


-PERTINENT FIGURES-

FIG. 1 ADSORPTION OF VARIOUS HYDROCARBONS ON SILICA GEL FROM THEIR SOLUTION IN LIQUID OXYGEN, PAGE 13. FIG. 2 FLUCTUATIONS IN THE PROPANE CONTENT OF THE LIQUID IN THE PRESSURE COLUMN AND IN THE MAIN CONDENSER, PAGE 14. FIG. 3 ADSORBER FOR THE OVERFLOW LIQUID FROM THE AUXILIARY VAPORIZER, PAGE 15. FIG. 4 TEMPERATURE CHANGES IN THE GEL LAYER REGENERATOR, PAGE 16.

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JOURNAL PROCEEDINGS - LINDE BER. TECH. WISS., NO. 10, 12-6 (NOV 1950) (IN GERMAN) (TRANSLATED BY F.E.E. GERMAN, NBS, TRANS. NO. T-14, APR.

123

-JOURNAL PROCEEDINGS-

OTHER INFORMATION - 0038 PAGES, 0000 FIGURES, 0000 TABLES, 0000 REFERENCES
AVIATORS BREATHING OXYGEN FROM AIRCRAFT CONVERTERS, EVALUATION OF

-ABSTRACT-

TWO SAMPLES OF AVIATORS BREATHING OXYGEN WERE ANALYZED FOLLOWING AN ACCIDENT IN WHICH A PILOT WAS KILLED. THE LIQUID OXYGEN HAD BEEN OBTAINED FROM THE AIRCRAFT CARRIER USS BENNINGTON. THE SAMPLES WERE TAKEN FROM LCX CONVERTERS OF AIRCRAFT WHICH HAD OBTAINED LOX FROM THE BENNINGTON AT THE SAME TIME AS THE AIRCRAFT INVOLVED IN THE FATAL CRASH. THE SAMPLES CONTAINED CONTAMINANTS FAR IN EXCESS OF THE MAXIMUMS ALLOWED UNDER SPECIFICATIONS. PILOT COMPLAINTS OF BAD ODORS, HEADACHES, NAUSEA, AND LOSS OF COORDINATION WERE ATTRIBUTED TO THE OXYGEN SUPPLY. IT IS SUGGESTED THAT THE TOXIC EFFECTS OF THE CONTAMINANTS MIGHT BE ENHANCED WHEN BREATHING PURE OXYGEN. IN ADDITION, ONE SAMPLE CONTAINED ACETYLENE IN EXCESS OF ITS SOLUBILITY IN LOX, CONSTITUTING AN EXPLOSIVE HAZARD. THE REPORT RECOMMENDS THAT MEANS OF MONITORING CONTAMINANT LEVELS IN LOX BE PROVIDED TO AIRCRAFT CARRIERS AND ALL LAND-BASED PLANTS WHICH DO NOT HAVE SUCH INSTRUMENTATION. A SUGGESTED INSTRUMENT IS A GAS CHROMATOGRAPH SUCH AS THE NRL TOTAL HYDROCARBON ANALYZER.

-PERTINENT FIGURES-

TAB. ANALYTICAL DATA FOR OXYGEN SAMPLES FROM AIRCRAFT CONVERTERS, PAGE 5

-SOURCE INFORMATION-

CORPORATE SOURCE - NAVAL RESEARCH LAB., WASHINGTON, D.C.
REPORT NUMBER - 6180-176.
OTHER INFORMATION - 0006 PAGES, 3001 FIGURES, 0000 TABLES, 0004 REFERENCES
Behavior of Liquid Oxygen

by

Balis, E.W.

02/00/57

Security Class: U/Unrestricted
Access Level: MTIS
Report Class: Incremental
Entry Eval.: Acceptable

Abstract:

This report reviews the chemical properties of liquid oxygen. A literature survey was made on the reactions of organic materials with liquid oxygen. Much of the information pertains to the use of organic materials with liquid oxygen as explosives, and to the explosion hazards of hydrocarbons with liquid oxygen. The author concludes that most reducing agents and hydrocarbons in contact with liquid oxygen constitute a potential explosive situation.

Source Information:

Corporate Source:
General Electric Co.

Report Number:
GDC-8614//SEC-45783

Publisher:
General Dynamics/Convair

Other Information:
0004 Pages, 0000 Figures, 0000 Tables, 0019 References

Original Page is Of Poor Quality
NEW DATA ON THE EXPLOSIVENESS OF LIQUID OXYGEN AND HYDROCARBONS (RUSSIAN)

by

GITTSEVICH, G.A.
EASYPOV, Z.B.
SAGAIDAK, V.J.

00/00/59

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Incremental Acceptable

-ABSTRACT-

EXPERIMENTS SHOWED THAT THE HEATING OF CYLINDER OIL, UNDER PRESSURE IN AIR, PRODUCES LOW-BOILING LIQUID AND GASEOUS HYDROCARBONS AND COKE, THE PRODUCTS OF THERMAL CRACKING. THESE PRODUCTS, MIXED WITH LIQUID OXYGEN, WERE TESTED FOR EXPLOSION SENSITIVITY, AND WERE FOUND TO BE MORE SENSITIVE TO IMPACT THAN NITROGLYCERINE. THE DATA SHOW THAT ACETYLENE SHOULD NOT BE CONSIDERED THE ONLY CAUSE OF EXPLOSIONS IN AIR SEPARATION EQUIPMENT. PRODUCTION OF CRACKING GASES IN RECIPROCATING COMPRESSORS, AND THEIR CONDENSATION WITH OXYGEN IN AIR SEPARATION EQUIPMENT, CAN EXPLAIN EXPLOSIONS IN CASES WHERE ACETYLENE AND LUBRICATING OIL WERE NOT FOUND. CLEANING OF THE PROCESS AIR, WITH REMOVAL OF ALL OILS AND OTHER HYDROCARBONS, CAN INSURE SAFE OPERATION OF AIR SEPARATION EQUIPMENT.

-PERTINENT FIGURES-

TAB. 1 COMPOSITION OF GASES OBTAINED BY THERMAL CRACKING OF OIL R-28 AT TEMPERATURES OF 200 AND 350 °C, PAGE 14/TAB. 2 MINIMUM PRESSURE OF Rupture of Diaphragms Necessary to Produce Explosions in Various Mixtures, PAGE 15

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THE STUDY OF AIR SEPARATION PLANT EXPLOSIONS (JAPANESE)

by

KITAGAWA, T.
ET AL

00/00/64

-ABSTRACT-

THIS RATHER EXTENSIVE REPORT GIVES DETAILS OF AIR SEPARATION PLANT ACCIDENTS (EXPLOSIONS) FOR THE PERIOD 1930-1963. 48 ACCIDENTS ARE DETAILED IN ALL. EXTENSIVE TABLES ARE INCLUDED WHICH SUMMARIZE THE DATA IN VARIOUS WAYS. E.G. YEAR, MONTH, LOCATION, TYPE, TYPE OF INDUSTRY, ETC. OF THE 48 ACCIDENTS INCLUDED 37 WERE DIRECTLY INVOLVED WITH AIR SEPARATION PLANTS. THE REPORT ALSO INCLUDES DETAILS OF HAZARDS, EXPLOSION LIMITS, IGNITION SOURCES, ETC. THE REPORT ALSO DISCUSSES THE VARIOUS TYPES OF AIR SEPARATION PLANTS AND GIVES A SUMMARY TABLE OF ALL AIR SEPARATION PLANTS IN JAPAN WITH DETAILS OF SIZE, USER, MAKER AND PURPOSE. THE ONLY HANDICAP TO THIS OTHERWISE FINE REPORT IS THAT IT IS IN JAPANESE.

-PERTINENT FIGURES-

TAB.1 CLASSIFICATION OF ACCIDENTS, PAGE 7//TAB.2 LOCATIONS OF ACCIDENTS, PAGE 7//TAB.3 CLASSIFICATION OF INDUSTRIES IN WHICH ACCIDENTS OCCURRED, PAGE 7//TAB.4 NUMBERS OF ACCIDENTS (1930-1963), PAGE 8//TAB.8 DETAILS OF EXPLOSIONS IN AIR SEPARATION PLANTS, PAGE 9//TAB. AIR SEPARATION PLANTS IN JAPAN AS OF OCTOBER, 1962, PAGE 31

-SOURCE INFORMATION-

JOURNAL PROCEEDINGS - EYUAN GIJUTSU VOL 17, NO. 3, 1-46 (1964)
OTHER INFORMATION - 0097 PAGES, 0010 FIGURES, 0016 TABLES, 0013 REFERENCES
THIS INVENTION RELATES TO EXPLOSIVES AND MORE PARTICULARLY TO AN EXPLOSIVE SOLUTION, COMPRISING FUEL MATERIAL DISSOLVED IN LIQUID OXYGEN. USERS OF OXYGEN AND OTHERS FAMILIAR WITH MANY OF ITS HAZARDS HAVE LONG LOCKED UPON FUEL-OXYGEN MIXTURES AS COMBUSTIONS TO BE AVOIDED WHENEVER POSSIBLE. THE INVENTION DESCRIBED HERE IN CONSIDERABLE DETAIL DEMONSTRATES THAT SOLUTIONS OF FUEL (E.G., METHANE, ETHANE, PROPAINE) IN LIQUID OXYGEN CONSTITUTE AN IMPROVED FORM OF EXPLOSIVE THAT CAN BE PREPARED, STORED AND USED IN RELATIVE SAFETY UNDER CERTAIN CONTROLLED CONDITIONS.

-PERTINENT FIGURES-

FIG. 1 DIAGRAMMATIC VIEW OF REFRIGERATED VESSEL CONTAINING SOLUTION OF FUEL IN LIQUID OXYGEN//FIG. 2 DIAGRAMMATIC VIEW OF INSULATED PARTITIONED VESSEL CONTAINING FUEL AND LIQUID OXYGEN IN SEPARATE COMPARTMENTS//FIG. 3 DIAGRAMMATIC VIEW ILLUSTRATING ONE METHOD OF PREPARING, HANDLING, AND STORING A SOLUTION OF FUEL IN LIQUID OXYGEN//FIG. 4 GRAPH OF SOLID-LIQUID EQUILIBRIA FOR METHANE-OXYGEN SYSTEM//FIG. 8 BUBBLE POINT CURVES AT 14.7, 50, 100, AND 200 PSIA FOR THE OXYGEN-ETHANE SYSTEM PLOTTED AGAINST TEMPERATURE, TOGETHER WITH PARTIAL PRESSURE CURVES AT 0.60 AND 2.05 PSI FOR ETHANE//FIG. 7 BUBBLE POINT CURVES AT 14.7, 50, 100, AND 200 PSIA FOR THE OXYGEN-METHANE SYSTEM PLOTTED AGAINST TEMPERATURE, TOGETHER WITH PARTIAL PRESSURE CURVES AT 0.79, 2.7, 5.4, AND 10.8 PSI FOR METHANE

-SOURCE INFORMATION-

REPORT NUMBER - U.S. PATENT NO. 2,939,778
OTHER INFORMATION - 0013 PAGES, 0008 FIGURES, 0000 TABLES, 0004 REFERENCES

ORIGINAL PAGE IS OF POOR QUALITY
HAZARD LEVEL OF HYDROCARBON FILMS IN SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN

by

KEAT, E.

09/00/61

-ABSTRACT-

THE OBJECT OF THIS WORK WAS TO DETERMINE REALISTIC STANDARDS OF CLEANLINESS IN SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN. AN ARBITRARY FIGURE OF 4 MILLIGRAMS PER SQUARE FOOT HAD BEEN PREVIOUSLY SET... EXAMINATION OF SYSTEMS THAT HAD CAUSED NO TROUBLE IN THE PAST. IT WAS FELT THAT THIS FIGURE WAS TOO LOW AND THAT EXPERIMENTAL DETERMINATION OF THE SAFE LEVEL SHOULD BE MADE TO SET SUCH STANDARDS. BASED ON THE EXPERIMENTS REPORTED HERE, THE RECOMMENDED SAFE LEVEL CONTAINMENT WITH HYDROCARBONS WITH VISCOSITY AND VAPOR PRESSURE SIMILAR TO HEXADECANE IS 100 MILLIGRAMS PER SQUARE FOOT.

-PERTINENT FIGURES-

FIG. 1 IGNITION APPARATUS USING GASEOUS OXYGEN PAGE 163//FIG. 2 IGNITION APPARATUS USING LIQUID OXYGEN PAGE 164//FIG. 3 IGNITION APPARATUS USING GASEOUS OXYGEN PAGE 164//FIG. 4 IGNITION APPARATUS USING LIQUID OXYGEN BEFORE IGNITION PAGE 165//FIG. 5 IGNITION APPARATUS USING LIQUID OXYGEN AFTER IGNITION PAGE 166//FIG. 6 UNBURNED HEXADECANE FILM AFTER SPARK IGNITION IN GASEOUS OXYGEN PAGE 166

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-SOURCE INFORMATION-

CORPORATE SOURCE -

AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -


OTHER INFORMATION -

0007 PAGES, 0008 FIGURES, 0001 TABLES, 0008 REFERENCES
III. SAMPLING AND DETECTION LIMITS OF IMPURITIES
DETERMINATION OF ACETYLENE IN LIQUID OXYGEN AND LIQUID NITROGEN

by

DEE, L.A.

07/18/61

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted NTIS Summary Good/Excel.

-ABSTRACT-

AN EVALUATION OF SEVERAL RAPID PROCEDURES FOR DETERMINING ACETYLENE IN LIQUID OXYGEN AND LIQUID NITROGEN IS PRESENTED. IN SEVERAL OF THE PROCEDURES THE ACETYLENE IS LOST WHEN THE INDICATING REAGENTS ARE ADDED. TWO PROCEDURES USING SILICA GEL AS AN ABSORBENT FOR ACETYLENE TO MINIMIZE THIS LOSS ARE DESCRIBED. THESE PROCEDURES ARE SENSITIVE, RAPID, EMPLOY INEXPENSIVE EQUIPMENT AND REQUIRE LITTLE TRAINING TO PERFORM.

-PERTINENT FIGURES-

TAB. 1 ACETYLENE CONCENTRATION PAGE 6

-BIBLIOGRAPHY-

AIR PRODUCTS, INC., ALLENTOWN, PA., ACETYLENE IN LIQUID OXYGEN TEST METHOD// BERTHELOT, M., COMPT. REND. 54, 1070 (1862)//HUGHES, ERNEST E., AND GORDON, RALPH, ANAL. CHEM. 31, 948 (1959)//ILLOVAY, LUDWIG, BER 32, 2697 (1899)//LINDE COMPANY, LOS ANGELES, CALIF., ACETYLENE IN LIQUID OXYGEN TEST METHOD.

-SOURCE INFORMATION-

CORPORATE SOURCE -
AIR FORCE SYSTEMS COMMAND, EDWARDS AFB, CALIF.
REPORT NUMBER -
SSD-TR-61-1//AD-446021
OTHER INFORMATION -
0008 PAGES, 0000 FIGURES, 0001 TABLES, 0005 REFERENCES

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134
SAMPLING PROCEDURE FOR LIQUID OXYGEN

by

JOHNS, S.D.

12/31/63

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted NTIS Summary Acceptable

-ABSTRACT-

THIS IS A PROPOSED STANDARD OPERATING PROCEDURE FOR TAKING SAMPLES FROM LIQUID OXYGEN STORAGE AND TRANSPORT TANKS. THE STANDARD IS TO BE USED BY THE DEPARTMENT OF DEFENSE AND UTILIZES A CRYOGENIC SAMPLER DEVELOPED BY COSMODYN. A BRIEF REVIEW OF THE HAZARDS ASSOCIATED WITH LIQUID OXYGEN HANDLING IS INCLUDED.

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-SOURCE INFORMATION-

CORPORATE SOURCE - NORTH AMERICAN AVIATION, INC., DOWNTY, CALIF.
REPORT NUMBER - QEL-MET-21-123-129//AD-459205

PERMISSIBLE CONTAMINATION LIMITS AND INSPECTION CRITERIA FOR LIQUID OXYGEN, LIQUID NITROGEN, RP-1 FUEL, GASEOUS OXYGEN, GASEOUS NITROGEN, INSTRUMENT AIR AND HELIUM, COMPONENTS AND HANDLING SYSTEMS, REVISION C

-ABSTRACT-

THE PURPOSE OF THE REPORT IS TO PROVIDE A STANDARD EXHIBIT OUTLINING THE CLEANLINESS CRITERIA, AND INSPECTION PROCEDURES, TO ASSURE THE DESIRED CLEANLINESS LEVEL OF COMPONENTS AND SYSTEMS HANDLING LIQUID OXYGEN, LIQUID NITROGEN, GASEOUS NITROGEN, HELIUM AND RP-1 FUEL UTILIZED IN BALLISTIC MISSILES. SPECIFICATIONS, INSPECTION AND CLEANING PROCEDURES AND STANDARDS ARE GIVEN.

-SOURCE INFORMATION-

CORPORATE SOURCE - BALLISTIC SYSTEMS DIV., NORTE AFB, CALIF.
REPORT NUMBER - BSD-EXHIBIT-61-3C//AD-615894
GAS-CHROMATOGRAPHIC METHOD FOR THE DETERMINATION OF POLLUTANTS IN AVIATION LIQUID OXYGEN. (METODO GASCROMATOGRAFICO PER LA DETERMINAZIONE DEGLI INQUINANTI NELL OSSIGENO LIQUIDO AVIO)

by

CIANETTI, E.
PECCL, G.
SCUDERI, G.

ABSTRACT

FOLLOWING AN EXPLANATION OF BASIC PRINCIPLES OF GAS CHROMATOGRAPHY AND SOME TOXICOLOGICAL CONSIDERATIONS OF REASONS FOR REDUCING MAXIMUM ALLOWABLE IMPURITIES IN OXYGEN, THE AUTHORS DESCRIBE A METHOD FOR QUICKLY DETERMINING BOTH ORGANIC AND INORGANIC IMPURITIES. ORGANIC IMPURITIES ARE DETERMINED WITH IONIZING FLAME GAS CHROMATOGRAPHY, INORGANIC ONES WITH A THERMISTOR SENSOR, IN TWO OPERATIONS, AFTER PRECONCENTRATION.

-PERTINENT FIGURES-

Figs. 1 THRU 4: GAS CHROMATOGRAPHY APPARATUS PAGES 30-1, 34-5//Figs. 5 THRU 13 CHROMATROGRAMS OF IMPURITIES IN OXYGEN PAGES 37-42//TABLE MAXIMUM ALLOWABLE CONTAMINANTS PAGE 32

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CORPORATE SOURCE: MINISTERO DELLA DIFESA AERONAUTICA, ITALY
JOURNAL PROCEEDINGS: RIV. MED. AERONAUT. SPAZ. VOL 28, 26-45 (JAN-MAR 1965)
OTHER INFORMATION: 0020 PAGES, 0013 FIGURES, 0000 TABLES, 0003 REFERENCES
ANALYSIS FOR TRACE HYDROCARBON CONTAMINANTS IN OXYGEN REBOILERS

by

LINDE, H.W.
SCHMACHER, G.E.

00/00/66

SECURITY CLASS: ACCESS LEVEL: REPORT CLASS: ENTRY EVAL:
Unrestricted Unlimited Summary Acceptable

-ABSTRACT-

IN CONNECTION WITH A PROGRAM TO STUDY THE CONCENTRATIONS OF HYDROCARBON CONTAMINANTS IN OXYGEN REBOILERS, A GAS CHROMATOGRAPHIC TECHNIQUE WAS DEVELOPED TO MEASURE C(3) THROUGH C(6) HYDROCARBONS AT THE 1 TO 15 PART-PER-BILLION LEVEL IN VAPOIZED LOX SAMPLES. THE PROCEDURE CONSISTED OF PASSING A LARGE VOLUME OF OXYGEN (3-15 LITERS) THROUGH A SHORT ALUMINA ADSORPTION COLUMN COOLED TO -78 DEGREES C FOLLOWING WHICH THE ADSORPTION COLUMN WAS SWITCHED INTO A GAS CHROMATOGRAPH CARRIER GAS STREAM. THE COOLANT WAS REMOVED AND THE COLUMN IMMERSED IN WATER AT 95 DEGREES C. THE HYDROCARBON CONTAMINANTS ELUTED FROM THE ADSORPTION COLUMN WERE CHROMATOGRAPHED ON A 12-FOOT DIBUTYL MALEATE COLUMN AT 40 DEGREES C. A SINGLE ANALYSIS COULD BE PERFORMED IN 30 MINUTES. THE REBOILERS OF FOUR OXYGEN PLANTS WERE SAMPLED AT WEEKLY INTERVALS OVER A SEVERAL MONTH PERIOD. PROPANE WAS REGULARLY FOUND IN CONCENTRATIONS AS HIGH AS 2300 PPB EACH WHILE THE PENTANES AND HEXANES WERE ORDINARILY BELOW THE DETECTABLE LIMITS BUT OCCASIONALLY ROSE TO THE 20 PPB RANGE.

-PERTINENT FIGURES-

FIG.1 MODIFIED GAS CHROMATOGRAPH, PAGE 368/FIG.2 FLOW DIAGRAM, PAGE 368/FIG.3 CHROMATOGRAM OF STANDARD GAS BLEND, PAGE 370/TAB.1 LIMITS OF HYDROCARBON DETECTION, PAGE 369/TAB.2 HYDROCARBONS IN REBOILER LCX, PAGE 371

-BIBLIOGRAPHY-


-SOURCE INFORMATION-

137
ABSTRACT

THIS SUPPLEMENTAL REPORT TO THE STUDY OF LIQUID OXYGEN CONTAMINATION DISCUSSES THE SAMPLING TECHNIQUES AND ANALYTICAL METHODS WHICH HAVE BEEN USED IN BOTH THE PRODUCTION AND USE OF LIQUID OXYGEN. THE SAMPLING TECHNIQUES AND ANALYTICAL METHODS WHICH ARE NEEDED AND USED HAVE BEEN ESTABLISHED TO MEET THE REQUIREMENTS OF SEVERAL DIFFERENT ASPECTS OF THE PROBLEM, SUCH AS, MONITORING FOR OXYGEN PURITY, MAINTENANCE OF COMBUSTIBLES BELOW DANGEROUS CONCENTRATION LEVELS, CONTROL OF SOLUBLE CONTAMINANTS, AND CONTROL OF SUSPENDED OR CONTAINED SOLID. SAMPLING AND ANALYTICAL TECHNIQUES WHICH ARE THE MOST ACCURATE, SENSITIVE, AND RELIABLE OF THOSE METHODS DISCUSSED, ARE RECOMMENDED. THE RECOMMENDED TECHNIQUES COVER PURITY, TOTAL HYDROCARBON, CARBON DIOXIDE, ACETYLENE, WATER, AND PARTICULATES FOR BOTH PRODUCTION STREAMS, AND LIQUID IN STORAGE.

PERTINENT FIGURES

FIG. 1 SAMPLING METHODS, PAGES 11, 12, AND 13/FIG. 2 ORSAT OXYGEN TEST, PAGE 22/FIG. 3 DEW POINT TEMPERATURE OF WATER VAPOR IN AIR, PAGE 29/TAB. 1 SELECTED PHYSICAL-CHEMICAL PROPERTIES OF LIQUID OXYGEN CONTAMINANTS, PAGE 3/TAB. 2 CO2 CONTAMINATION STUDY AT MARTIN-DENVER 75 T/D LIQUID OXYGEN FACILITY, PAGE 16/TAB. 3 TYPICAL CONTAMINANT CONCENTRATIONS IN HIGH PURITY LOX, PAGE 26

BIBLIOGRAPHY

VARYING INSTRUMENTS FOR AND METHODS OF CONTAMINATION ANALYSIS ARE DESCRIBED. A METHOD OF CONCENTRATING CONTAMINANTS FROM ADSORBENT REGENERATION GAS IS PRESENTED. A TOTAL HYDROCARBON ANALYZER THAT OXIDIZES HYDROCARBONS TO CO(2), WHICH IS THEN SENSED WITH AN INFRARED DETECTOR IS DESCRIBED. A QUICK METHOD OF SPOT CHECKING FOR ACETYLENE CONTAMINATION IN LUX IS DESCRIBED. A FAST, CONTINUOUS FLOW METHOD FOR MEASURING THE SURFACE AREA OF ADSORBENTS IS GIVEN AND AN APPARATUS FOR OBTAINING A REPRESENTATIVE GAS SAMPLE FROM A LIQUID STREAM IS REVIEWED. A DETONATION WHICH OCCURRED IN THE HEAT EXCHANGER OF A HYDROGEN LIQUEFACTION PLANT IS REVIEWED. IT WAS DETERMINED AFTER EXTENSIVE TESTS THAT N(2)O AND NOT CO(2) WAS THE MAJOR CONTAMINANT IN THE HEAT EXCHANGER. FURTHER EXPERIMENTAL TESTS REVEALED THAT N(2)O IS JUST AS GOOD AN OXIDANT AS OXYGEN AND WILL DETONATE WHEN MIXED WITH HYDROGEN IN THE PROPER PROPORTIONS. A SPECIAL CATALYST WAS USED TO CATALYTICALLY CONVERT THE N(2)O TO NITROGEN AND WATER IN A HYDROGEN ATMOSPHERE AND AN INFRARED ANALYZER WAS USED TO DETECT N(2)O IMPURITIES.

-PERTINENT FIGURES-

FIG. 1 FLOW DIAGRAM, HYDROGEN PURIFICATION SYSTEM, PAGE 58
FIG. 2 FLOW DIAGRAM, SAMPLING PROCEDURE, PAGE 59
FIG. 3 FLOW DIAGRAM, CONTAMINANT CONCENTRATION APPARATUS, PAGE 59
FIG. 4 TYPICAL NITROUS OXIDE CONTENT MONITORING CHART FROM INFRARED ANALYZER, PAGE 60
FIG. 5 FLOW DIAGRAM, CONTINUOUS FLOW BUNAUER-EMMETT-TELLER APPARATUS, PAGE 62
FIG. 6 FLOW DIAGRAM, PORTABLE HYDROCARBON ANALYZER, PAGE 63

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CORPORATE SOURCE -
AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -
CRYOG. SAFETY CONF., PROC. OF., SEMINAR NO. 1, 57-68, ALLENTOWN, PA., JUL 1959

PUBLISHER -
141
ABSTRACT

Adsorbents are no longer used for drying applications only, but are now used extensively for selectively removing contaminants such as CO(2), nitrogen compounds, and hydrocarbons from gas process streams. The adsorption characteristics and capacities of several alumina compounds are discussed. Silica gel is formally used to adsorb hydrocarbons from crude Lox streams. The adsorption capacity of silica gel for some of the lighter hydrocarbons at 90 K is given. The desorption characteristics of the lighter hydrocarbons from silica gel adsorbers at various temperatures are discussed. The operating principles of open and closed dryer reactivation cycles are discussed. Many aspects of water and hydrocarbon adsorption and desorption are discussed at the end of the article. Questions concerning the adsorption characteristics of the various adsorbents, reactivation temperatures, dew points from dryers, adsorbent reactivation times, oil contamination, and adsorbent deterioration are answered.

-PERTINENT FIGURES-

Fig. 1 Diagram of air separation cycle, page 121. Fig. 2 Moisture-holding comparison curves for P-1 and H-151 alumina, page 122. Fig. 3 Open dryer reactivation cycle, page 122. Fig. 4 Closed dryer reactivation cycle, page 123. Fig. 5 Adsorptive capacities, page 124. Fig. 6 Hydrocarbon content of adsorber reactivation gas, page 124.

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ANALYSIS OF HYDROCABON IMPURITIES IN OXYGEN PLANT STREAMS
BY GAS CHROMATOGRAPHY

by

PARKS, J.C.
HINKLE, E.A.

00/00/63

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
J/Unrestricted Unlimited Summary Good/Excel.

-ABSTRACT-

HYDROCARBONS IN GENERAL, AND ACETYLENE IN PARTICULAR, PRESENT A
VERY SPECIAL HAZARD WHEN PRESENT AS IMPURITIES AT THE
PARTS-PPM MILLION LEVEL IN LIQUID OXYGEN PLANT STREAMS. FOR THIS
REASON SOME TYPE OF AUTOMATIC, CONTINUOUS PROCESS INSTRUMENTATION
IS DESIRED WHICH SERVES AS A HYDROCARBON MONITOR. ACETYLENE
ANALYSIS HAS BEEN ASSIGNED THE HIGHEST PRIORITY IN THIS ARTICLE
WHILE THE MONITORING OF OTHER LIGHT HYDROCARBONS IS OF INTEREST
PROVIDED THEY ARE READILY DETECTABLE. TWO INSTRUMENT TYPES,
PROCESS INFRARED AND PROCESS GAS CHROMATOGRAPHY WITH A HIGH
SENSITIVITY DETECTOR, APPEARED ADEQUATE FOR SUCH ANALYSIS. AT
THE TIME ACTIVE STUDY BEGAN ON THIS APPLICATION CONSIDERABLE WORK
HAD BEEN DONE BY VARIOUS INSTRUMENT COMPANIES IN UPGRADING PROCESS
INFRARED ANALYZERS TO SUCH A DEGREE THAT THE DESIRED RELIABILITY
AND ACETYLENE DETECTION LIMIT COULD BE OBTAINED. WITH ALL THE WORK
THAT HAD BEEN DONE, THE BEST OBTAINABLE INFRARED ANALYZER WAS
CONSIDERED MARGINAL AT BEST FOR THE PROPOSED APPLICATION. PROCESS
CHROMATOGRAPHY WITH A HIGH SENSITIVITY TYPE IONIZATION DETECTOR
WAS JUST BECOMING AVAILABLE AS THE STUDY BEGAN. DETECTORS OF THIS
TYPE WERE PERFORMING QUITE SATISFACTORILY IN LABORATORY TYPE
CHROMATOGRAPHS BUT UNATTENDED CONTINUOUS PROCESS TYPE INSTRUMENT
APPLICATIONS WERE BOTH QUITE NEW AND FEW IN NUMBER. HOWEVER,
INCREASED SENSITIVITY AND THE ABILITY TO MONITOR MORE THAN A
SINGLE COMPONENT WERE TWO FACTORS FAVORING CHROMATOGRAPHY OVER
INFRARED ANALYSIS. WHEN A COMMERCIAL PROCESS CHROMATOGRAPH WITH A
HYDROGEN FLAME DETECTOR BECAME AVAILABLE ON A CONSIGNED BASIS
THE DECISION TO USE CHROMATOGRAPHY, AS OPPOSED TO INFRARED, WAS
MADE.

-PERTINENT FIGURES-

FIG.1 COLUMN CONFIGURATION FOR SEPARATING DESIRED COMPONENTS, PAGE
31//FIG.2 SECTION OF RECORDER CHART WITH SEVERAL COMPLETE ANALYSES
SHOWN, PAGE 33// FIG.3 FRESH AIR FEED SAMPLE SYSTEM, PAGE
34//FIG.4 VAPORIZER DEVELOPED FOR SYSTEM ELIMINATED SAMPLING
PROBLEMS, PAGE 35//FIG.5 OVER-ALL LIQUID OXYGEN SAMPLE SYSTEM,
PAGE 35.
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PARKS, J. C. AND HINKLE, E. A. A NEW CALIBRATION METHOD FOR PROCESS GAS CHROMATOGRAPHY, ISA 8TH ANNUAL SYMPOSIUM ON INSTRUMENTAL METHODS OF ANALYSIS, CHARLESTON, W. VA., APRIL 30 -- MAY 2, 1962

-SOURCE INFORMATION-

CORPORATE SOURCE - MONSANTO C.0. , TEXAS CITY, TEX.

JOURNAL PROCEEDINGS - SAFETY IN AIR AND AMMONIA PLANTS, VOL 5, 32-6 (PROC. OF A SYMP. AT DENVER, COLO., AUG 26-9, 1962)

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OTHER INFORMATION - 0005 PAGES, 0005 FIGURES, 0001 TABLES, 0001 REFERENCES

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ANALYZING LIQUID O(2) FOR CONTAMINANTS

by

MCDONNELL, F.G.; J3.
GLASS, J.A.
EAUSS, G.W.

00/00/67

SECURITY CLASS: J/Unrestricted
ACCESS LEVEL: Unlimited
REPORT CLASS: Incremental
ENTRY EVAL: Good/Excel.

-ABSTRACT-

THIS REPORT CONCERNS AN INFRARED METHOD FOR SPOT SAMPLE ANALYSIS OF LIQUID OXYGEN FOR NITROUS OXIDE, CARBON DIOXIDE, AND SOME HYDROCARBONS. THE METHOD WAS DEVELOPED TO IDENTIFY AND MEASURE CONTAMINANTS ENTERING AND CONCENTRATING IN AIR SEPARATION PLANTS, IT PROVIDED CLUES WHICH LED TO THE ASSIGNMENT OF CAUSE OF A REBOILER EXPLOSION DUE TO THE DEPOSITION OF CO-CRYSTALS OF NITROUS OXIDE AND ACETYLENE IN LIQUID OXYGEN.

-SOURCE INFORMATION-

CORPORATE SOURCE -
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JOURNAL PROCEEDINGS -
SAFETY IN AIR AND AMMONIA PLANTS, VOL 9, 6-9 (PROC. OF THE 11TH ANNUAL SYMF, 1966)

PUBLISHER -
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, N.Y.

OTHER INFORMATION -
0004 PAGES, 0005 FIGURES, 0001 TABLES, 0000 REFERENCES
EVALUATION OF LIQUID OXYGEN SAMPLER (TTU-131/E)

by

MCNAMARA, W.D.

12/00/65

-ABSTRACT-

(UNCLASSIFIED) A REPORT OF COMPARISON TESTS BETWEEN U.S. AIR FORCE CRYOGENIC SAMPLERS AP MOD 4 AND TTU 131/E. NINE CONCURRENT SAMPLES WERE TAKEN WITH EACH SAMPLER. IT WAS FOUND THAT THE TTU 131/E WAS A SUPERIOR SAMPLER AND SHOULD BE ADOPTED BY THE CANADIAN AIR FORCE PROVIDED CERTAIN CHANGES ARE MADE IN THE EQUIPMENT AND INSTRUCTIONS.

-PERTINENT FIGURES-

FIG. 6-1 CRYOGENIC SAMPLER, TYPE TTU 131/E, EXPLODED VIEW
FIG. 5 LIQUID BATCH SAMPLER ASSEMBLY, MODEL 4, EXPLODED VIEW
TAB. 1 COMPARISON OF SAMPLER HANDLING CHARACTERISTICS
TAB. 2 DISTRIBUTION OF SAMPLES BY LOCATION
TAB. 3 RESUMÉ OF LIQUID OXYGEN SAMPLING USING TTU 131/E SAMPLE

-SOURCE INFORMATION-

CORPORATE SOURCE - CANADIAN FORCES MEDICAL SERVICE, TORONTO, INST. OF AVIATION MEDICINE
REPORT NUMBER - 65-TM-6/AO-397944
CONTRACT NUMBER - ASCC-TPA-491-14
OTHER INFORMATION - 0014 PAGES, 0004 FIGURES, 0004 TABLES, 0000 REFERENCES

Original page is of poor quality.
FOREIGN MATERIALS IN LIQUID OXYGEN NORMALLY COME FROM THE ATMOSPHERE AND FROM THE PRODUCTION PROCESS WHERE IT IS NOT ECONOMICALLY FEASIBLE TO COMPLETELY REMOVE THEM. THIS ARTICLE SETS FORTH THE COMPOSITION OF COMMERCIAL LIQUID OXYGEN AND DESCRIBES METHODS OF PURIFICATION AND ANALYSIS.

-PERTINENT FIGURES-
TAB. 2 MAXIMUM LIMITS OF CONTAMINANTS FOR BREATHING OXYGEN LIQUID AND MISSILE PROPELLANT OXYGEN, PAGE 546

-BIBLIOGRAPHY-
2. GLUECKAUF, THE COMPOSITION OF ATMOSPHERIC AIR, COMPENDIUM OF METEOROLGY, AM. METEOR. SOC., BOSTON (1951)/C. P. SMITH, ANALYTICAL METHODS FOR LIQUID OXYGEN, 1958 CRYOGENIC ENGINEERING CONFERENCE PROCEEDINGS.
SAMPLING AND ANALYSIS PROCEDURE FOR DETERMINING LIQUID OXYGEN CONTAMINATION IN THE JUPITER WEAPONS SYSTEM

by

TORTE, D.A.
KARTI, K.A.

07/26/61

-ABSTRACT-

PROCEDURES ARE SET FORTH FOR DETERMINING LIQUID OXYGEN (LOX) CONTAMINATION IN THE JUPITER MISSILE WEAPONS SYSTEM. INSTRUCTIONS ARE ESTABLISHED FOR THE QUALITY CONTROL OF LIQUID OXYGEN USED AS A PROPELLANT IN THE SM78 MISSILE.

-SOURCE INFORMATION-

CORPORATE SOURCE - CRYSLER CORP., DETROIT, MICH.
REPORT NUMBER - AD-290896/TV-ME-425-J
SPONSOR - MOBILE AIR MATERIAL AREA, BROOKLEY AFB, ALA.
CONTRACT NUMBER - CONTRACT AF-35620
OTHER INFORMATION - 0043 PAGES, 0008 FIGURES, 000 TABLES, 0000 REFERENCES
MEANS OF DETECTION AND QUANTIFICATION OF CONTAMINANTS IN CLOSED
ECOLOGICAL SYSTEMS ARE DISCUSSED. ATMOSPHERIC CONTAMINANTS HAVE
BEEN IDENTIFIED, QUANTITATED, AND SUSPECTED FROM STUDIES CONDUCTED
ON NUCLEAR SUBMARINES, SPACECRAFT AND SIMULATORS. AT THE USAP
SCHOOL OF AEROSPACE MEDICINE, TECHNIQUES HAVE BEEN DEVELOPED FOR
SAMPLING AND GROSSLY IDENTIFYING CONTAMINANTS THAT TEND TO OCCUR
IN SIMULATORS. THIS INCLUDES SAMPLES OBTAINED NOT ONLY DURING
NORMAL CONDITIONS, BUT ALSO DURING ABNORMAL CONDITIONS AS
CHARACTERIZED BY A FIRE DURING ONE OF THE EXPERIMENTS.
EXPERIMENTAL DATA ARE REPORTED. CONTAMINANT LEVELS ALSO HAVE BEEN
EXPLORED IN OTHER GROUND-BASED SIMULATORS. FOR EXAMPLE, ONE
EXPERIMENT CONDUCTED AT BOEING WAS TERMINATED DUE TO EXCESS
CONTAMINANT LEVELS WHICH PRODUCE PHYSIOLOGICAL ABNORMALITIES. A
COMPLETE KNOWLEDGE OF THE CONTAMINANT PROBLEM IS, THEREFORE,
IMPORTANT, TO DETERMINE THE TOXICOLOGICAL ASPECTS AND ESTABLISH
THRESHOLD LIMIT VALUES (TLV) FOR THE LONG-TERM CLOSED ECOLOGICAL
SYSTEM. IT IS NECESSARY TO IDENTIFY AND QUANTITATE THE ATMOSPHERIC
CONTAMINANTS WITHIN THE SYSTEM. TECHNIQUES TO OBTAIN SAMPLES WITH
SUFFICIENT CONCENTRATION OF CONTAMINANTS TO PERMIT ANALYSIS ARE
INCLUDED.

-PERTINENT FIGURES-
TAB. 1 COMPOUNDS ISOLATED FROM A SEALED ATMOSPHERE DURING A FIRE,
PAGE 255// TAB. 2 DISTRIBUTION OF COMPOUNDS BY TRAPPING CYLINDER
TEMPERATURE, PAGE 256// TAB. 2 RESULTS OF PRELIMINARY EVALUATION,
EFFICIENCY AND RECOVERY, PAGE 257// TAB. 4 ANIMAL EXPERIMENT
CONTAMINANT AND CONCENTRATION AT GROUND LEVEL, PAGE 258// TAB. 5
ANIMAL EXPERIMENT CONTAMINANT AND CONCENTRATION AT REDUCED
PRESSURE, PAGE 259// FIG. 3 ISOLATION SYSTEM FOR MICRO-CONSTITUENTS
IN A SEALED ATMOSPHERE, PAGE 261

-SOURCE INFORMATION-
CORPORATE SOURCE -
AEROSPACE MEDICAL DIV., BROOKS AFB, TEX.
REPORT NUMBER -
151
LIQUID OXYGEN SAMPLER EVALUATION.

by

WRIGHT, E.R.
PERLMAN, M.

12/31/69

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
J/Other Govt./Contr. Summary Acceptable

-ABSTRACT-

A COMPARATIVE ANALYSIS OF NAVY, AIR FORCE AND A RECENTLY DEVELOPED COMMERCIAL LIQUID OXYGEN SAMPLER WAS MADE. EVALUATION OF THE SAMPLERS WAS MADE ON THE BASIS OF EFFICIENCY, RELIABILITY, CONVENIENCE, SAFETY AND COST.

-PERTINENT FIGURES-

TAB. 1 TEST RESULTS OF SAMPLING PAGE 7//FIG. 1 LIQUID OXYGEN SAMPLING WITH NAVY G-276 SAMPLING SYSTEM PAGE 8//FIG. 2 SAMPLER PREPARED FOR SAMPLING PAGE 9//FIG. 3 PICTORIAL SCHEMATIC OF CRYOGENIC SAMPLER PAGE 10//FIG. 4 SAMPLE BOTTLE PAGE 11//FIG. 5 EXTERNAL VIEW OF SAMPLER PAGE 12//FIG. 6 BENDEX GU-137-AL SAMPLER AND GU-138-AL CYLINDER PAGE 13//FIG. 7 UNDERSIDE VIEW OF GU-137-AL SAMPLER PAGE 14//FIG. 8 BENDEX GU-138-AL SAMPLER CYLINDER PAGE 15

-SOURCE INFORMATION-

CORPORATE SOURCE - NAVAL AIR DEVELOPMENT CENTER, JOHNsville, PA.
REPORT NUMBER - NADC-MA-6956//AD-870165L
OTHER INFORMATION - 0015 PAGES, 0008 FIGURES, 0001 TABLES, 0000 REFERENCES

153
INHOMOGENEITY OF OXYGEN SAMPLES IN THE COSMODYNE CS-4.4
SAMPLER

by

VAN SOMEREN, H.
BECK, H.C.

03/00/68

-ABSTRACT-

IT WAS FOUND THAT THE DETERMINATION OF CONTAMINANTS IN LIQUID
OXYGEN SAMPLES TAKEN WITH THE COSMODYNE CS-4.4 SAMPLER IN SOME
INSTANCES GIVES IRREPRODUCIBLE VALUES. THE EFFECT WAS FOUND TO BE
DUE TO A FRACTIONATION PROCESS OF THE LIQUID OXYGEN SAMPLE IN THE
SAMPLE CUP. AN EXPERIMENTAL CONFIRMATION COULD BE OBTAINED BY
DRAWING THE SAMPLE FROM THE COSMODYNE THROUGH ONE OF THE SIDE
TUBES. AN ESTIMATE OF THE ERRORS IN THE RESULT OF THE ANALYSES WAS
OBTAINED BY CALCULATIONS ON SOME HYPOTHETICAL CASES.

-PERTINENT FIGURES-

TAB.1 ANALYSIS OF SAMPLES, TAKEN VIA DIFFERENT OUTLETS OF THE
COSMODYNE, PAGE 3/TAB.2 THE ANALYSIS OF SAMPLES TAKEN FROM THE
COSMODYNE UNDER DIFFERENT CONDITIONS, PAGE 4

-SOURCE INFORMATION-

CORPORATE SOURCE -
NATIONAL DEFENSE RESEARCH ORGANIZATION TNO, THE HAGUE,
NETHERLANDS

REPORT NUMBER -
1964-3//TOKK II 50651//AD-633438

OTHER INFORMATION -
0006 PAGES, 0001 FIGURES, 0003 TABLES, 0000 REFERENCES
HIGH-PURITY PRODUCTS FROM AN AIR SEPARATION PLANT

by

DINAPOLI, P.N.
SASS, A.H.

00/00/70

SECURITY CLASS: Unrestricted
ACCESS LEVEL: Unlimited
REPORT CLASS: Summary
ENTRY EVAL: Acceptable

-ABSTRACT-

THE SIMULTANEOUS PRODUCTION OF HIGH-PURITY OXYGEN, NITROGEN, AND ARGON IS OFTEN REQUIRED FROM AIR SEPARATION PLANTS TO MEET TODAY'S NEEDS OF THE MILITARY, SPACE, AND COMMERCIAL MARKETS. DETAILED PRODUCT SPECIFICATIONS AS DEVELOPED BY THE VARIOUS SEGMENTS OF THE INDUSTRY ARE PRESENTED TOGETHER WITH ACTUAL PLANT PERFORMANCE DATA. GAS CHROMATOGRAPHY IS USED TO MEASURE INDIVIDUAL COMPONENT IMPURITIES IN OXYGEN AND TO MONITOR HYDROCARBON CONTENT AT VARIOUS LOCATIONS WITHIN THE PLANT.

-PERTINENT FIGURES-

- TABLE 1 TYPICAL HIGH-PURITY PRODUCT SPECIFICATIONS PAGE 10/ TABLE 3 GAS CHROMATOGRAPHIC ANALYSIS PAGE 12

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CORPORATE SOURCE - AMERICAN CRYOGENICS, INC., ATLANTA, GA.
JOURNAL PROCEEDINGS - ADVANCE CRYOG. ENG. VOL 15, 399-405 (PROC. CRYOGENIC ENG. CONF., 15TH, LOS ANGELES, CALIF., JUN 16-18, 1969)
PUBLISHER - PLENUM PRESS, INC.
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FURTHER CONTRIBUTION TO THE DETERMINATION OF POLLUTANTS IN AVIATION LIQUID OXYGEN.

by

CIANETTI, E.
PECCI, G.

00/00/68

-ABSTRACT-

REFINEMENTS TO THE GAS CHROMATOGRAPHIC METHOD USED IN THE DETERMINATION OF POLLUTANTS IN AVIATION LIQUID OXYGEN ARE REPORTED. THE REFINEMENTS INVOLVE THE USE OF A COLUMN OF SQUALENE WITH A LENGTH OF 8 m AND A DIAMETER OF 6 TIMES 5 mm FOR ANALYZING ORGANIC POLLUTANTS. THE INNOVATION CONSISTS IN THE FACT THAT AN ANALYSIS MADE ON THIS COLUMN IS FOLLOWED BY ANOTHER ANALYSIS MADE ON ANOTHER COLUMN WHICH IS FILLED WITH FLORISIL AND HAS A LENGTH OF 30 cm AND A DIAMETER OF 6 TIMES 5 mm. THE AMOUNTS OF ACETYLENE AND ETHYLENE THAT CAN BE METERED ARE APPRECIABLY LESS THAN THOSE PERMITTED BY THE ACCEPTANCE SPECIFICATION.

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IANNETTI, V., PECCI, G., RASS. CHIM., 1966, 3

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CORPORATE SOURCE - AERONAUTICA MILITARE, LABORATORI, DIVISIONE CHIMICA-TECNOLGOICA, ROME, ITALY.


OTHER INFORMATION - 1560 PAGES, 1000 FIGURES, 10000 TABLES, 10000 REFERENCES
CHECK OF OXYGEN PURITY FOR ONBOARD RESPIRATORS BY MEANS OF IR ABSORPTION SPECTROPHOTOMETRY. (IN ITALIAN).

by

MARANGONI, C.
GIUSTI, A.
DICARLO, E.

00/00/67

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
1/Unrestricted Unlimited Incremental Acceptable

-ABSTRACT-


-PERTINENT FIGURES-

FIG. 1 SYSTEM FOR DIRECT INJECTION PAGE 694/FIG. 2 SYSTEM FOR INJECTION IN OXYGEN FLOW IN A HEATED CHAMBER PAGE 695/FIG. 3 PARTICULARS OF THE CELL ANALYZER PAGE 695/FIG. 4 OXYGEN SPECTRUM WITH IMPURITIES PAGE 697/FIG. 5 SAME AS FIG. 4 EXCEPT WITH CARBON TETRACHLORIDE AND TRICHLOROETHYLENE PAGE 699.

-SOURCE INFORMATION-

CORPORATE SOURCE - AERONAUTICA MILITARE, LABORATORI, ROME, ITALY.
JOURNAL PROCEEDINGS - IV. MED. AERON. SPAZIALE, V. 30, 693-703 (DEC 1967).
OTHER INFORMATION - 0011 PAGES, 0007 FIGURES, 0000 TABLES, 0000 REFERENCES
THE DETERMINATION OF TRACE IMPURITIES IN LIQUID OXYGEN FOR BREATHING BY INFRARED METHODS

by

CORBETT, J. K.

10/00/67

SECURITY CLASS ACC2SS LEVEL REPORT CLASS ENTRY EVAL.
1/Other Govt./Ccntr. Incremental Good/Excel.

-ABSTRACT-

A DOUBLE-BEAM INFRA-RED SPECTROPHOTOMETER HAS BEEN MODIFIED BY THE ADDITION OF A PAIR OF 40 METRE LONG-PATH CELLS AND ORDINATE SCALE EXPANSION TO MAKE POSSIBLE THE DETECTION AND QUANTITATIVE DETERMINATION OF TRACES OF IMPURITIES IN LIQUID OXYGEN FOR BREATHING. THE EFFECTS OF PRESSURE BROADENING ARE CONSIDERED AND THE LOWER LIMITS OF DETECTION ARE LISTED FOR THE IMPURITIES DETERMINED. THIS SPECTROPHOTOMETER PROVIDES AN ACCURATE AND RAPID METHOD FOR THE DETERMINATION OF THE TRACE IMPURITIES IN LIQUID OXYGEN FOR BREATHING TO AIR STANDARD 14/9A. ONLY INFRARED INACTIVE MOLECULES SUCH AS NITROGEN, HELIUM, ARGON, ETC., ARE INCAPABLE OF DETECTION BY THE METHOD DESCRIBED.

-PERTINENT FIGURES-

TAB. 1 SPECTROSCOPIC DATA FOR IMPURITIES, PAGE 11/TAB. 2 PRESSURE BROADENING OF A CONSTANT PARTIAL PRESSURE OF ETHYLENE, PAGE 5/TAB. 3 PRESSURE SENSITIVITY, PAGE 6/TAB. 6 CALIBRATION DATA FOR GASES, PAGE 10/TAB. 7 MINIMUM DETECTION LIMITS, PAGE 13/TAB. 10 CONCENTRATIONS OF IMPURITIES FOUND IN OXYGEN, PAGE 14

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J. K. CORBETT, INFRA-RED TRACE GAS ANALYSIS. PAPER DELIVERED AT THE CHEMICAL INSPECTORATE, A. D. CONFERENCE, OCTOBER, 1965

-SOURCE INFORMATION-

CORPORATE SOURCE - CHEMICAL INSPECTORATE, LONDON, ENGLAND
REPORT NUMBER - RPE-TM-417/AD-826520
OTHER INFORMATION - 0019 PAGES, 0003 FIGURES, 0011 TABLES, 0020 REFERENCES
AVIATORS BREATHING OXYGEN FROM AIRCRAFT CONVERTERS, EVALUATION OF

-ABSTRACT-

TWO SAMPLES OF AVIATORS BREATHING OXYGEN WERE ANALYZED FOLLOWING AN ACCIDENT IN WHICH A PILOT WAS KILLED. THE LIQUID OXYGEN HAD BEEN OBTAINED FROM THE AIRCRAFT CARRIER USS PENNINGTON. THE SAMPLES WERE TAKEN FROM LOX CONVERTERS OF AIRCRAFT WHICH HAD OBTAINED LOX FROM THE BENNINGTON AT THE SAME TIME AS THE AIRCRAFT INVOLVED IN THE FATAL CRASH. THE SAMPLES CONTAINED CONTAMINANTS FAR IN EXCESS OF THE MAXIMUMS ALLOWED UNDER SPECIFICATIONS. PILOT COMPLAINTS OF BAD ODORS, HEADACHES, NAUSEA, AND LOSS OF COORDINATION WERE ATTRIBUTED TO THE OXYGEN SUPPLY. IT IS SUGGESTED THAT THE TOXIC EFFECTS OF THE CONTAMINANTS MIGHT BE ENHANCED WHEN BREATHING PURE OXYGEN. IN ADDITION, ONE SAMPLE CONTAINED ACETYLENE IN EXCESS OF ITS SOLUBILITY IN LOX, CONSTITUTING AN EXPLOSIVE HAZARD. THE REPORT RECOMMENDS THAT MEANS OF MONITORING CONTAMINANT LEVELS IN LOX BE PROVIDED TO AIRCRAFT CARRIERS AND ALL LAND-BASED PLANTS WHICH DO NOT HAVE SUCH INSTRUMENTATION. A SUGGESTED INSTRUMENT IS A GAS CHROMATOGRAPH SUCH AS THE NRL TOTAL HYDROCARBON ANALYZER.

-PERTINENT FIGURES-

Table: Analytical Data for Oxygen Samples from Aircraft Converters, Page 5

-SOURCE INFORMATION-

CORPORATE SOURCE - NAVAL RESEARCH LAB., WASHINGTON, D.C.
REPORT NUMBER - 6180-176
OTHER INFORMATION - 0006 PAGES, 0001 FIGURES, 0000 TABLES, 0004 REFERENCES

ORIGINAL PAGE IS OF POOR QUALITY
ANALYSIS OF TRACES OF CONTAMINANTS IN BREATHING OXYGEN WITH A HELIUM DETECTOR AND AN ELECTRON CAPTURE DETECTOR

by

CASTELLO, G.

00/00/71

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Incremental Good/Excel.

-ABSTRACT-

A METHOD IS DESCRIBED WHICH ALLOWS THE DETERMINATION OF A FEW PARTS PER BILLION OF IMPURITIES IN BREATHING OXYGEN FOR PILOTS AND FOR THERAPEUTIC PURPOSES. FIXED GASES AND CHLORINATED SOLVENTS ARE ANALYSED BY GAS CHROMATOGRAPHY AND DETECTED WITH A HELIUM DETECTOR AND AN ELECTRON CAPTURE DETECTOR, RESPECTIVELY. THE ANALYSIS TIME IS ABOUT 15 MIN. THE PROPOSED METHOD IS SUFFICIENTLY SENSITIVE AND RAPID FOR ROUTINE ANALYSIS OF CONTAMINANTS IN LIQUID OXYGEN TO BE USED FOR BREATHING PURPOSES. THE METHOD CAN BE APPLIED TO THE ANALYSIS OF AIR POLLUTANTS AND TO THE DETERMINATION OF THE PURITY OF GASES.

-PERTINENT FIGURES-

FIG. 4 ANALYSIS ON FCRAPAK Q COLUMN, STANDARD MIXTURE CONTAINING CH(4), H(2), ETHANE, ETHYLENE, ACETYLENE AND PROPANE, PAGE 121
FIG. 5 CALIBRATION CURVES OBTAINED WITH THE EXPONENTIAL DILUTION FLASK, PAGE 122
FIG. 6 ANALYSIS OF CHLORINATED COMPOUNDS ON AN APIZZON L COLUMN WITH ECD, PAGE 123
TAB. 2 MAXIMUM ALLOWED CONCENTRATION VALUES OF CONTAMINANTS IN BREATHING OXYGEN FOR PILOTS, PAGE 118
TAB. 3 SENSITIVITY OF HELIUM DETECTOR TO CONTAMINANTS, PAGE 123
TAB. 5 PRACTICAL LIMIT OF DETECTION AT MAXIMUM SENSITIVITY FOR 1 ML OF SAMPLE AT ATMOSPHERIC PRESSURE, PAGE 124

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THRESHOLD LIMIT VALUES, 27TH ANN. MEETING AMER. CONF. GOVERNMENTAL IND. HYGIENISTS, HOUSTON, 1965
PRONTUARIO DELLE SOSTANZE CHIMICHE PERICOLOSE, E.N.P.I., ROMA, 1968
CONTAMINATION SENSORS

by

ANTHONY, H.V.
CREW, J.G.
LARUE, E.P.
McDONALD, J.P.
PICCONI, M.

09/12/67

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U/Unrestricted Unlimited Incremental Acceptable

-ABSTRACT-

THIS PAPER PRESENTS THE RESULTS OF A NASA-SPONSORED STUDY, COMPLETED IN APRIL 1966, INTENDED TO PROVIDE A BASIS FOR POSSIBLE EVENTUAL USE OF AUTOMATIC CONTAMINATION SENSORS AND MONITORS CAPABLE OF BEING INSTALLED IN A FLUID SYSTEM, AND OF REMOTELY INDICATING PARTICLE-CONTAMINATION COUNT, AMOUNT OF MOISTURE PRESENT, Purity OF THE FLUID, OR SOME COMBINATION OF THESE. SOME INFORMATION CONCERNING MECHANICAL SAMPLING IS ALSO INCLUDED.

-SOURCE INFORMATION-

CORPORATE SOURCE - MARTIN MARIETTA CORP., DENVER, COLO.
REPORT NUMBER - N66-29328
JOURNAL PROCEEDINGS - CURRENT AND ADVANCED CONCEPTS IN INSTRUMENTATION AND AUTOMATION, AEC/NASA CONTAMINATION CONTROL SYMP., PROC., N5-62, ALBUQUERQUE, N. MEX., SEP 12-4, 1967
OTHER INFORMATION - 0016 PAGES, 0012 FIGURES, 0000 TABLES, 0003 REFERENCES.
A STUDY OF TRACE IMPURITIES IN AVIATORS BREATHING OXYGEN

by

DREW, C. M.
SCHOWEN, F. L.
SMITH, S. R.

ABSTRACT

A STUDY OF AVIATORS BREATHING OXYGEN FROM PRESSURE AND LIQUID APPARATUS HAS BEEN CARRIED OUT TO DETERMINE THE IMPURITIES THAT ARE RESPONSIBLE FOR NAUSEA AND ANOXIATION REPORTED BY SOME PILOTS. AN ANALYTICAL METHOD USING GAS CHROMATOGRAPHY AND MASS SPECTROMETRY HAS BEEN USED TO DETERMINE THE IDENTITY AND CONCENTRATION OF THE CONTAMINANTS IN THE BREATHING OXYGEN. A POSSIBLE MECHANISM WHEREBY THESE CONTAMINANTS AFFECT THE PILOTS HAS BEEN PROPOSED AND RECOMMENDATIONS TO PURIFY THE BREATHING OXYGEN HAVE BEEN MADE. THE REPORT CONCLUDES WITH A NUMBER OF RECOMMENDATIONS MOSTLY CENTERING AROUND PURGING OF THE STORAGE TANKS, TRANSFER Carts, AND MOST ESPECIALLY THE CONVERTER TANKS IN THE AIRCRAFT. THE USE OF ABSORBENTS IN THE LOW-PRESSURE FEED LINES IN THE AIRCRAFT IS ALSO RECOMMENDED.

-PERTINENT FIGURES-

FIG. 2 RUN NO. 511 LIQUID OXYGEN FROM CONVERTER, PAGE 13//FIG. 3 RUN NO. 503 STORAGE TANK NO. 1, PAGE 14//FIG. 4 RUN NO. 504 GAS FROM CONVERTER, PAGE 15//FIG. 7 RUN NO. 507 NEWLY REPLIED STORAGE TANK, PAGE 18//FIG. 8 RUN NO. 508 OXYGEN LIQUEFIED FROM CYLINDER, PAGE 19//TAB. 1 ANALYSIS OF OXYGEN SAMPLES, PAGES 24-26

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CORPORATE SOURCE - NAVAL ORDNANCE TEST STATION, CHINA LAKE, CALIF. RESEARCH DEPT.

REPORT NUMBER - NAVOED-R-5309/NOTS-1887

OTHER INFORMATION - 0026 PAGES, 0012 FIGURES, 0001 TABLES, 0006 REFERENCES
AIR PRODUCTS DISCOVERED THAT LIQUID OXYGEN TESTED FOR PRESENCE OF ACETYLENE BY THE ILOSTVEY SOLUTION SHOWED NO ACETYLENE, WHILE IN REALITY IT CONTAINED 1 TO 1.5 PPM ACETYLENE. CONCURRENT WITH THIS THE SAMPLES SHOWED THE PRESENCE OF CARBON DIOXIDE IN EXCESS OF ITS SOLUBILITY LIMIT. IT WAS POSTULATED THAT THE ACETYLENE WAS ABSORBED BY THE SOLID CARBON DIOXIDE. PROOF OF THE LATTER HAS NOT BEEN FOUND BUT ONE CAN STATE THAT THE PRESENCE OF EXCESS CARBON DIOXIDE SOMEHOW MASKS THE PRESENCE OF ACETYLENE.
CONTAMINANT DETECTOR FOR AVIATORS BREATHING OXYGEN

by

MILLER, R.L.
ROBINSON, C.E.
IKELS, K.G.

05/00/72

-ABSTRACT-

THIS PAPER IS CONCERNED WITH FINDING A PORTABLE OXYGEN ANALYZER WHICH WILL PERMIT THE DETECTION OF CONTAMINANTS AT OR BELOW ALLOWABLE LEVELS. THIS IS NEEDED TO INVESTIGATE PHYSIOLOGICAL INCIDENTS INVOLVING AIRCRAFT CREWS WHERE CONTAMINATION OF THE BREATHING OXYGEN SUPPLY IS SUSPECTED. THE ANALYSES ARE CURRENTLY DONE AT REGIONAL LABORATORIES WHERE TIME DELAYS AND SAMPLING TECHNIQUES HAMPER INVESTIGATIONS. DISCUSSION OF THE ANALYTICAL REQUIREMENTS AND DEVELOPMENT OF AN AVIATORS BREATHING OXYGEN ANALYZER AND CONTAMINANT DETECTOR. TWO APPROACHES CURRENTLY UNDER DEVELOPMENT ARE DESCRIBED, ONE APPROACH IS BASED ON GAS CHROMATOGRAPHY AND THE OTHER ON THE USE OF A COMMERCIALLY DEVELOPED PORTABLE INFRARED ANALYZER. THE AUTHORS PROPOSE A SIX MONTHS TEST OF THE TWO INSTRUMENTS TO MAKE A DECISION REGARDING THE BEST APPROACH.

-PERTINENT FIGURES-

TAB. 1 ALLOWABLE CONSTITUENTS IN AVIATORS BREATHING OXYGEN, PAGE 7

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CASIHELLO, G., ANALYSIS OF TRACES OF CONTAMINANTS IN BREATHING OXYGEN WITH A HELIUM DETECTOR AND AN ELECTRON CAPTURE DETECTOR, J. CHROMATOGRAPHY 58, 117-125 (1971)

-SOURCE INFORMATION-

CORPORATE SOURCE - SCHOOL OF AEROSPACE MEDICINE, BROOKS AFB, TEX.
REPORT NUMBER - A72-28253
JOURNAL PROCEEDINGS - AEROSPACE MEDICAL ASSOC. ANNUAL SCIENTIFIC MEETING, 43RD, BAL HARBOUR, FLA., MAY 8-11, 1972

166.
THE DETERMINATION OF HYDROCARBON TRACES IN ATMOSPHERIC AIR AND LIQUID OXYGEN

by

THEER, J.

02/27/63

-ABSTRACT-

FOR A LONG TIME A RAPID METHOD OF DETERMINING TRACES OF HYDROCARBONS IN THE AIR SUCKED INTO AND THE LIQUID OXYGEN PRODUCT OF AIR SEPARATION PLANTS HAS BEEN Sought. THIS IS NEEDED TO AVOID DANGERS OF EXPLOSIONS DUE TO THE ACCUMULATION OF HYDROCARBONS ESPECIALLY ACETYLENE. THIS PAPER DESCRIBES A GAS CHROMATOGRAPH WITH A MICROFLAME IONIZATION DETECTOR. A 10 ML SAMPLE CAN BE PROCESSED IN 5 MINUTES WITH A SENSITIVITY OF 5 PARTS PER MILLION AND IN 15 MINUTES A SENSITIVITY OF 10 PARTS PER BILLION CAN BE ACHIEVED. THE SAMPLER AND INSTRUMENT HAVE BEEN TESTED IN CONTINUOUS OPERATION.

-PERTINENT FIGURES-

TAB. P.6 HYDROCARBON CONTENT OF ATMOSPHERIC AIR FROM VARIOUS REGIONS OF GERMAN DEMOCRATIC REPUBLIC//FIG. 3 HYDROCARBON CHROMATOGRAM FOR LIQUID OXYGEN, PAGE 7//FIG. 4 CONCENTRATION APPARATUS FOR HYDROCARBONS FROM ATMOSPHERIC AIR, PAGE 8//FIG. 5 HYDROCARBON CHROMATOGRAM FOR ATMOSPHERIC AIR, PAGE 7

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CORPORATE SOURCE: INSTITUTE FOR CHEMICAL AND REFRIGERATING EQUIPMENT, DRESDEN, EAST GERMANY

REPORT NUMBER: 168
ANALYTICAL METHODS FOR LIQUID OXYGEN

by

SMITH, C.P.

00/00/60

SECURITY CLASS Access Level REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Summary Acceptable

-ABSTRACT-

LIQUID OXYGEN ANALYSES ARE CUSTOMARILY MADE FOR PROCESS CONTROL, PRODUCT PURITY AND TO AVOID HAZARDS. USUALLY ANALYTICAL INFORMATION REQUIRED FOR PROCESS CONTROL IS NOT EXTENSIVE. USE OF MODIFIED OXSAT APPARATUS FOR MANUAL DETERMINATION OF THE OXYGEN CONTENTS OF VARIOUS LIQUID SAMPLES IS ROUTINE IN MOST PLANTS. IN ADDITION TO THE ABOVE GENERAL METHOD THE AUTHOR REVIEWS METHODS FOR DETERMINING OTHER IMPURITIES SUCH AS CARBON DIOXIDE (INFRARED TECHNIQUES), ACETYLENE (IllSOVAY METHOD), HYDROCARBONS (CHEMICAL METHODS), SOLID MATTER (FILTERS) AND WATER. THE AUTHOR SPECIFICALLY DISCUSSES ORGANIC TRACE CONTAMINANTS IN BREATHING OXYGEN SUPPLIES FOR AIRCRAFT.

-SOURCE INFORMATION-

CORPORATE SOURCE -
UNION CARBIDE CCRP., TICONAWANDA, N.Y.

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PRODUCTION CONTROL OF LIQUID OXYGEN AT COMMERCIAL FACILITIES

by

SMITH, C.P.

11/00/64

SECURITY CLASS ACCESS LEVEL REPORT CLASS ENTRY EVAL.
U/Unrestricted Unlimited Summary Acceptable

-ABSTRACT-

THIS IS A SHORT SUMMARY PAPER CONCERNING PRODUCTION CONTROL IN COMMERCIAL AIR SEPARATION PLANTS. INCLUDED ARE SECTIONS ON HAZARD CONTROL, PRODUCTION CONTROL FOR EFFICIENCY, PRODUCTION CONTROL FOR QUALITY, PRODUCT HANDLING AND PRODUCT ANALYSIS.

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SAFETY IN AIR AND AMMONIA PLANTS, VOLUMES 1 THROUGH 5, PUBLISHED BY THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS AT 345 EAST 47TH STREET, NEW YORK 17, NEW YORK

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