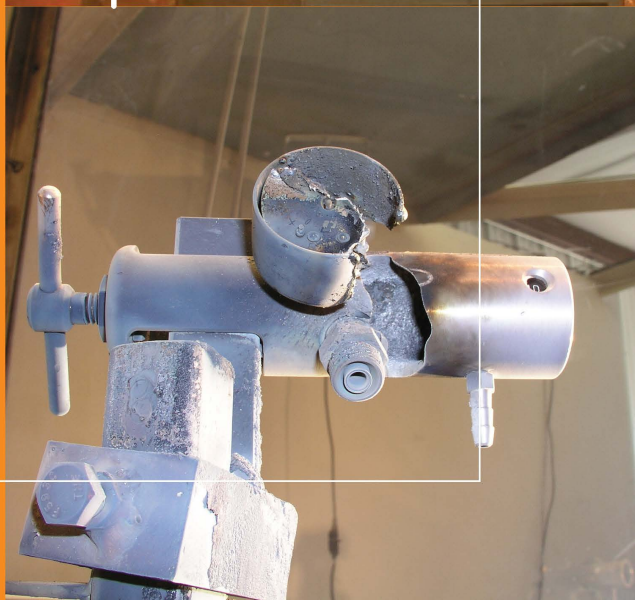

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Selected Technical Papers

Flammability and Sensitivity of Materials in Oxygen—Enriched Atmospheres: 14th Volume

STP 1596

Editors
Samuel Edgar Davis
Theodore A. Steinberg

SELECTED TECHNICAL PAPERS
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Foreword

THIS COMPILATION OF Selected Technical Papers, STP1596, *Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres: 14th Volume,* contains peer-reviewed papers that were presented at a symposium held April 13–15, 2016, in San Antonio, Texas, USA. The symposium was sponsored by ASTM International Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres.

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Failure and Incident Investigations

Research on Materials and Operations

Overview

STP1596 is the fourteenth set of Special Technical Papers (STP) originating from the ASTM Committee G04 focusing on the *Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres*. The thirteen previous STP volumes originating from the ASTM G04 committee are: 812, 910, 986, 1040, 1111, 1197, 1267, 1319, 1395, 1454, 1479, 1522, and 1561. Copies of these STP volumes are available from ASTM International.

The ASTM Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres continues to grow in its international appeal. The fourteenth symposium was attended by a number of professionals representing several countries. These included the United States, Australia, Germany, Canada, France, India, the United Kingdom, and Belarus. A number of professionals from other nations also attended the symposium and shared important information in person even though they were unable to submit a formal paper for publication.

As with the past STPs, the fourteenth volume expands upon the objectives that have been carried forward since the first ASTM Committee G04 STP was published in 1983. These objectives include:

- Review the current research on polymers and metals ignition and combustion;
- Overview principles of oxygen systems design and issues related to materials compatibility with oxygen;
- Contribute to the knowledge on the most current risk management concepts, practices, approaches, and procedures used by individuals and organization involved in the design, use, retrofitting, maintenance, and cleaning of oxygen systems;
- Review of accident/incident case studies related to oxygen systems and oxygen handling procedures;
- Provide research on new compounds or techniques to clean oxygen systems in order to make these systems safer for users;
- Provide the most current data related to the flammability and sensitivity of materials in oxygen-enriched atmospheres to designers, users, manufacturers and maintainers of oxygen components and systems and to support Committee G04's Technical and Professional Training Course on Fire Hazards in Oxygen Systems;

- Discuss enhancement, development, and use of standards sponsored by ASTM Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres; and
- Provide a readily accessible reference addressing oxygen compatibility.

The fourteenth volume consists of a group of peer-reviewed papers that were presented at the Committee G04's Fourteenth International Symposium held in San Antonio, Texas, USA, in April 2016. The volume consists of twenty-four papers on topics related to ignition and combustion of metals and non-metals, ignition and combustion of metals, oxygen compatibility of components and systems, analysis of ignition and combustion, failure analysis and safety, cleaning and cleanliness verification, new test methods, failure investigations, and includes aerospace, military, scuba diving, and industrial oxygen applications.

The papers presented in the fourteenth volume are arranged into five groups that offer a variety of valuable information. The first paper is a keynote address that was provided by Walter D. Downing of the Southwest Research Institute (SwRI) located in San Antonio, Texas. This address outlines how standards developed by ASTM play an important role in the research work conducted at SwRI.

The second group of papers consists of four papers focusing on test methods, including proposals for new test methods and modifications of existing test methods to improve the data derived from them. The first paper, submitted by NASA White Sands Test Facility, highlights improvements to autogenous ignition testing by using induction heating. The second paper, submitted by WHA International, focuses on the importance of statistical issues with the data generated by adiabatic compression testing. The third paper, submitted by NASA White Sands Test Facility, proposes improvements to ASTM G72 by improving the fuel to oxidizer ratios. The fourth paper, submitted by WHA International, deals with testing in low pressure oxygen applications, such as those used in hyperbaric systems.

The third group of papers consists of five papers focusing on cleaning methods, cleaning solvents, cleanliness verification, and contamination control. The first paper, submitted by NASA Marshall Space Flight Center, provides a thorough overview of the test program conducted by NASA to determine an adequate replacement for the current standard NASA oxygen system and hardware cleaning solvent, AK-225G, and the replacement solvent selected. The second paper, submitted by NASA Stennis Space Center, highlights the independent assessment program that NASA implemented for the AK-225G replacement selection effort. The third paper, submitted by NASA White Sands Test Facility, provides recommendations for improving the compatibility test methods that will ultimately lead to permitting the limited use within oxygen systems of materials that are flammable in oxygen. The fourth paper, submitted by NASA Marshall Space Flight Center, evaluates the risks that fibers and particulates pose in oxygen systems and the rationale behind the

existing cleanliness requirements. The fifth paper, submitted by WHA International, centers on the issues with non-volatile residues and their effect on the risks of fires in oxygen systems.

The fourth group of papers consists of five papers focusing on investigations of incidents and failures involving oxygen systems in the government and private industries. The first paper, submitted by the Indian Institute of Technology, provides an accurate and thorough evaluation of the fatal oxygen fire that occurred in 2012 at a steel plant in India. The second paper, submitted by NASA White Sands Test Facility, highlights a hydrocarbon fire that occurred inside one of their test chambers. The third paper, submitted by AEI Corporation of Colorado and WHA International, provides a detailed analysis of a fire that took place in a liquid oxygen bulk delivery tank. The fourth paper, submitted by WHA International, details the failure analysis of a gate valve fire within a liquid oxygen system. The fifth paper, submitted by WHA International, provides information about an incident involving a stainless steel plug valve that used silicone lubricant and an acetal resin valve seat.

The fifth group consists of nine papers that discuss research being conducted on materials and operations for oxygen systems. The first paper, submitted by Materion Corporation, highlights the qualities of ToughMet 3, a new material developed by Materion that may be well suited for oxygen system applications. The second paper, submitted by the ParisTech National Research Center in France, details the mechanisms and diagnostics for metals ignition in oxygen by utilizing a laser ignition mechanism. The third paper, submitted by Queensland University of Technology in Australia, provides a comparison of the combustion products of bulk aluminum burning in oxygen at both the normal gravity of Earth and a reduced gravity. The fourth paper, submitted by the National Academy of Sciences of Belarus in the Republic of Belarus, proposes steady-state jet modeling techniques for the combustion of cylindrical aluminum rods in high-pressure oxygen. The fifth paper, submitted by NASA White Sands Test Facility, highlights the methods to use containment boxes to mitigate fires in oxygen-enriched conditions. The sixth paper, submitted by Praxair Corporation, proposes a new promoted ignition-combustion test method for aluminum comprising heat exchangers. The seventh paper, submitted by the BAM Federal Institute for Materials Research and Testing in Germany, proposes a new international standard for oxygen endurance test for oxygen cylinder valve materials. The eighth paper, submitted by Queensland University of Technology in Australia, proposes a method to increase fire safety in oxygen systems by evaluating nonmetals in a near adiabatic compression process. The ninth paper, submitted by NASA White Sands Test Facility, details the facility's research on correlating the flammability of materials conducted at different oxygen concentrations and partial pressures.

The fourteenth volume of *Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres* provides a diverse source of new information to air

separation industries, oxygen manufacturers, manufacturers of components for oxygen and other industrial gases service, manufacturers of materials intended for oxygen service, and users of oxygen and oxygen-enriched atmospheres, including aerospace, medical, industrial gases, chemical processing, steel and metals refining, as well as military, commercial, or recreational diving.

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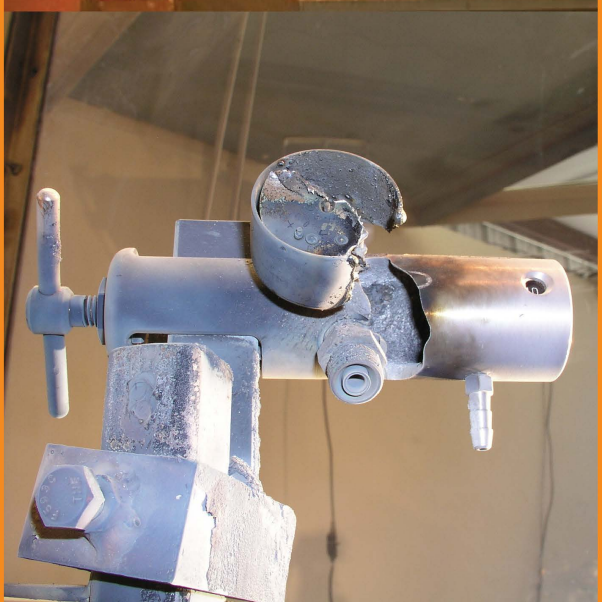

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