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STP 1522

Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres

12th Volume

JAI Guest Editors
Hervé Barthélémy
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Foreword

THIS COMPILATION OF THE *JOURNAL OF ASTM INTERNATIONAL (JAI)*, STP1522, on *Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres: 12th Volume*, contains only the papers published in JAI that were presented at a symposium in Berlin, Germany, on October 7, 2009–October 9, 2009 and sponsored by ASTM Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres.

The JAI Guest Editors are Hervé Barthélémy, Air Liquide Corporate, Paris, France, Theodore Steinberg, Queensland University of Technology, Brisbane, Australia, Christian Binder, BAM Federal Institute for Materials Research and Testing, Berlin, Germany, and Sarah R. Smith, NASA White Sands Test Facility, Las Cruces, NM, USA.

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Overview

This is the twelfth Special Technical Publication (STP) originating from ASTM Committee G04 focusing on the Flammability and Sensitivity of Materials in Oxygen-Enriched Environments. As in the past STPs, the twelfth volume expands upon the objectives that have been carried forward since the first 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 organizations involved in the design, use, retrofitting, maintenance, and cleaning of oxygen systems;
- Review accident/incident case studies related to oxygen systems and oxygen handling procedures;
- 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 and Oxygen Systems Operation and Maintenance;
- Discuss enhancement, development, and use of standards sponsored by ASTM Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres;
- Provide a readily accessible reference addressing oxygen compatibility.

The twelfth Volume consists of a group of peer-reviewed publications from the *Journal of ASTM International* that were also presented at Committee G04's Twelfth International Symposium held in Berlin, Germany in October 2009. The volume contains 29 papers on topics related to ignition and combustion of non-metals, ignition and combustion of metals, oxygen compatibility of components and systems, analysis of ignition and combustion, failure analysis and safety, and includes aerospace and industry oxygen applications.

The keynote address at the Twelfth International Symposium was presented by Joseph Slusser, Senior Engineering Associate—Materials, Air Products and Chemicals, Inc, Allentown, PA USA. He has been involved with materials selection for oxygen and other strong oxidizers since joining Air Products and Chemicals, Inc in 1980 and has been a member of Committee G04 since 1997. Mr. Slusser has been active in Committee activities, is currently the Chairman of Committee G04, and also serves on the ASTM Committee on Standards. In addition, he has been involved with several CGA task groups related to oxygen compatibility issues and has published several papers on oxygen and nitrogen trifluoride compatibility topics.

Eight papers focus on ignition and combustion of metals. A study is presented by Praxair on the promoted Ignition of cobalt and nickel alloys in oxygen enriched atmosphere. They found that although nickel and cobalt alloys are generally considered as having superior combustion resistance in oxygen—enriched atmospheres, flammability testing is necessary prior to service as there may be considerable variation in their promoted ignition-combustion resistance. Queensland University of Technology presents two papers; one where they show that heat transfer is the rate-limiting mechanism for the heterogeneous burning of cylindrical iron rod and, in the other, introduce the concept of the "melting rate triangle" to aid in the discussion of burning metallic materials. The fourth paper in this section presents results on the ignition of contaminated aluminum by mechanical impact in liquid oxygen. There are two papers, one submitted by NASA White Sands Test Facility and one by Queensland University of Technology that, together, define and validate the burn criterion used in the recent rewrite of ASTM Committee G04's G124 standard on burning metallic materials. The last two papers in this section are submitted by Wendell Hull & Associates; one a test method developed to quantify the ignitability of metallic materials and the other presenting the test result for metallic filters for use in high-pressure oxygen.

Six papers are related to the use of non-metallic materials in oxygen-enriched atmospheres. The first, submitted by NASA Marshall Space Flight Center, looks at the compatibility of brass-filled PTFE as compared to other fluorinated polymers. The second and third papers in this section, submitted by BAM, first investigate the ignition of nonmetallics in NITROX mixes as encountered in typical SCUBA diving applications followed by a discussion on the importance of quality assurance and batch testing in the qualification of nonmetallic materials for oxygen service. The fourth paper on nonmetallics, submitted by Air Liquide, provides information on the type and quantity of combustion products produced when nonmetallic materials burn in oxygen systems. The final two papers in this section are submitted by NASA White Sands Test Facility with the first evaluating the time it takes for nonmetallics exposed to oxygen to no longer be considered "oxygen enriched", and the second looking at the effect of oxygen concentration on the AIT and ignitability by pneumatic impact of nonmetallic materials.

Eight papers focus on issues related to oxygen compatibility of components and systems. Four papers are by NASA White Sands Test Facility; the first is a study on a frictional heating of contaminated metals in a liquid oxygen rocket engine propulsion system, the second evaluated the arc ignition characteristics of common handheld devices in oxygen-enriched atmospheres and, both the third and fourth looked at particle impact ignition in a high pressure quick disconnect and in the Advanced Crew Escape Suits. Two papers submitted by Oxygen Safety Consultants and Wendell Hull & Associates evaluate the fire hazards in steel mill oxygen systems and within valve-integrated pressure regulators. The seventh paper in this section

looks at reactions within a sealed aluminum cavity within a reboiler while the final paper discusses vacuum super insulated liquid oxygen piping and vessels.

The final section of the STP contains six papers related to specific applications (or other areas). Two papers presented here by Wendell Hull & Associates, look in detail at adiabatic compression testing with the first presenting a background on this important testing and the second providing a proposed framework within which the severity of the test can be related to real components in service. The next two papers are an attempt to help clarify the mechanism behind flow friction ignition. The first provides a discussion on the importance of tribiocharging of particle contaminants while the other uses CFD analysis as an explanation of this ignition phenomena. Next a submission from NASA Marshall Space Flight Center verifies the purge equation used in the G124 metals standard. Finally, some work is presented on Chlorine Trifluoride reactivity and testing.

The twelfth *Volume on Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres* provides a diverse source of new information to air separation industry, oxygen manufacturers, manufacturers of components for oxygen and other industrial gases service, manufacturers of materials intended for oxygen and other industrial gases service, and users of oxygen and oxygen-enriched atmospheres aerospace, medical, industrial gases, chemical processing, steel and metals refining, as well as to military-commercial-recreational diving.

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