FLAMMABILITY and SENSITIVITY of MATERIALS in OXYGEN-ENRICHED ATMOSPHERES

Seventh Volume

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Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres: Seventh Volume

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The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

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Foreword

The papers in this publication, *Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres: Seventh Volume,* were presented at the symposium of the same name, held in Denver, CO on 16–17 March 1995. The symposium was sponsored by ASTM Committee G-4 on Compatibility and Sensitivity of Materials in Oxygen-Enriched Atmospheres. Dwight D. Janoff of Lockheed Engineering and Science Company in Houston, TX, William T. Royals of Pratt and Whitney in West Palm Beach, FL, and Mohan V. Gunaji of NASA-WSPF in Las Cruces, NM, presided as chairmen and are the editors of the resulting publication.

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Overview

The purpose of the symposium on flammability and sensitivity of materials in oxygen-enriched atmospheres was to build upon the foundation provided by the previous symposia. The overall objectives were to:

- provide a reference text on oxygen compatibility which is a subject that is not addressed often in accessible literature.
- build a reference of risk management concepts and practices used in designing oxygen systems.
- provide a database to support the use of ASTM Committee G04 guides, practices, and test methods.
- serve as a guide to Committee G04 members in their future efforts to address the problems of oxygen system safety.

This volume is the seventh in the series which includes STPs 812, 910, 986, 1040, 1111, and 1197. These volumes are an important resource on the proper use of materials in oxygen-enriched atmospheres. Committee G-4's contribution to this subject also includes ASTM Standard

- Guide for Evaluating Nonmetallic Materials for Oxygen Service (G 63),
- Guide for Designing Systems for Oxygen Service (G 88),
- Practice for Cleaning Methods for Material and Equipment Used in Oxygen-Enriched Environments (G 93), and
- Guide for Evaluating Metals for Oxygen Service (G 94),

as well as a standard guide for introducing the hazards of oxygen systems that is still under development. In addition, G-4 has responsibility over six test ASTM standard test methods

- Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment (G 72),
- Test Method for Ignition Sensitivity of Materials to Gaseous Fluid Impact (G 74),
- Test Method for Determining Ignition Sensitivity of Materials to Mechanical Impact in Pressurized Oxygen Environments (G 86),
- Test Method for Determination of Soluble Residual Contamination in Materials and Components by Soxhlet Extraction (G 120),
- Test Method for Evaluating the Effectiveness of Cleaning Agents (G 122), and
- Test Method for Measuring Liquid and Solid Material Fire Limits in Gaseous Oxidants (G 125),

as well as test methods for determining the combustion behavior of metallic materials, and residual contamination in materials by ultrasonic extraction that are under development. In addition to the test methods and guides, ASTM Committee G-4 has also developed standard practices for evaluating and using non-chlorofluorocarbon cleaning agents. In addition to ASTM standards, ASTM Committee G-4 also offers a Standards Technology Training Course entitled "Controlling Fire Hazards in Oxygen Systems." In this course, attendees are taught to apply available resources to improve the safety of oxygen handling systems. The Committee presents this volume as a further contribution to the subject.

This Special Technical Publication (STP) consists of a keynote address and five sections. In his keynote paper, Benz discusses the accomplishments of ASTM Committee G-4 since its formation in 1975. He examines the committee's adherence to its charter and points out major milestones. He also identifies areas that need more attention in the future.

The first section presents four papers on test method development. Haselmaier and Powell introduces a seal configuration tester. This test apparatus subjects elastomeric o-rings to dynamic and frictional loads in a high pressure oxygen atmosphere. The method is presented as a new approach for the evaluation of elastomeric materials in their use configuration. Binder et al. present a test method for determining ignition and burn-through resistance of components by gaseous oxygen impact. This method has been adopted widely in Europe. The test apparatus and data interpretation are described. Yentzen presents the design of the oxygen systems for a high heat flux facility. The facility, located at Stennis Space Center in Mississippi, was designed to test the high temperature performance of materials for the National Aerospace Plane. The system design philosophy and materials selection decisions are described. Steinberg and Scown present new test capabilities for materials flammability testing in oxygen-enriched atmospheres. The test system configuration is similar to those presented in other studies. However, additional instrumentation is incorporated into the test apparatus to monitor pressure, temperature, and real-time mass of the sample.

The second section presents six papers on the ignition and combustion of metallic materials. Zawierucha et al. present a study on the ignition and combustion of light metals in oxygen-enriched atmospheres. The study focuses on an aluminum alloy and two titanium alloys. Both Gunaji et al. and Schmees investigate the ignition and combustion of titanium-based alloys. Gunaji et al. summarize data on ignition by frictional heating and threshold pressure for promoted combustion. They point out that titanium is combustible at pressure as low as 13.8 kPa (2 psia). Schmees presents a study on the effect of beryllium additions on the burn propensity of titanium alloys. Changes in combustion resistance are explained by changes in phase equilibria caused by beryllium. Sircar et al. present a study on the promoted combustion resistance of pure metals in oxygen. This study is intended to provide a baseline for investigating the effects of alloying on the combustion behavior of metals. Gugliemini et al. have performed a study on the flammability of metals in another strong oxidizer other than oxygen. Their study of the flammability of engineering alloys in fluorine and nitrogen trifluoride shows that metals have increased flammability in fluorine when compared to oxygen at the same pressure. Barthelemy and Muller present an investigation on reaction of molten/burning aluminum with liquid oxygen. This paper expands on the discussion of the reactivity of aluminum packings in liquid air distillation columns presented in previous symposia. Test results are theoretical predictions of peak pressures caused by rapid vaporization are presented.

The third section is comprised of four papers on the ignition and combustion of nonmetals. Dees et al. present a study of polymers as ignition sources during particle impact. They investigate the propensity of high-velocity polymer particles to ignite metals. Hshieh and Beeson investigate the rate of heat release and ignition properties of epoxy/fiberglass composites in enriched oxygen using cone calorimetry. Rimanosky et al. present a study of the effects of forced convection, oxygen concentration, and flow path on the flammability behavior of simulated electronics boxes. The last paper in this section is authored by Jain et al. They present a study of compatibility of materials with high-pressure air.

The fourth section features two papers on cleaning for oxygen service. The first, presented by Chou et al. describes a protocol for evaluating non-chlorofluorocarbon cleaning agents. The second, presented by Engelsberg, describes a laser-assisted cleaning process.

The fifth section features two papers. Starr presents a comparison of oxygen user training courses. Newton et al. present a case study of an oxygen-acetylene torch failure as a result of flashback reactions.

These papers confirm that the objectives of the symposium were met. This volume (in conjunction with the six previous ones in the series) provides a reference text on oxygen compatibility and builds a reference of risk management concepts and practices used in designing oxygen systems. These volumes provide a database to support the use of ASTM Committee G-4 guides, practices, and test methods. Also, this volume will serve as a guide to Committee G-4 members in their future efforts to address the problems of oxygen system safety.

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