Overview

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

- provide a reference text on a subject that is not widely addressed in accessible literature,
- build a reference of the concepts and practices used in designing oxygen systems,
- provide a data base to support the use of ASTM Committee G-4 guides and standards, and
- serve as a guide to Committee G-4 members in their future efforts to address the problems of oxygen-use safety.

This volume, in addition to those from the previous symposia (STP 812, 910, 986, and 1040), is an important resource on the subject of the proper use of materials in oxygen-enriched environments. The G-4 Committee's contribution to the resources on the subject also include four standard guides (G63, G88, G93, and G94), three standard test methods (G72, G74, and G86), and a fourth test method for determining the promoted ignition and combustion properties of metallic materials that is currently being balloted. The latest contribution is a Standards Technology Training course entitled, "Controlling Fire Hazards in Oxygen-Handling Systems." In this course, attendees are taught to apply the available resources to improve the safety of oxygen-handling systems. We are confident that this volume will be a welcome contribution to the subject.

The book comprises a keynote address and six sections. In the keynote address, Dr. Irvin Glassman discusses the combustion fundamentals of low-volatility materials in oxygen-enriched environments. He describes the principles underlying ignition, flame spread, and mass burning of condensed-phase materials. Analytical developments of the parameters affecting flammability are presented and interpreted in light of metal and polymer combustibility in oxygen-enriched environments. Finally, he discusses the limitations of limiting oxygen index and heat release tests in light of the fundamentals developed.

The first section presents six papers on the development and evaluation of test methods. Sanders and Currie discuss the development of a flame penetration test to evaluate materials for protective clothing to be worn by personnel who may be subjected to the effects of a fire in an oxygen system. Tapphorn, Shelley, and Benz present two newly developed methods to examine flammability characteristics of polymers in oxygen-enriched environments. Janoff, Pedley, and Bamford present a modified pneumatic impact test that addresses the problems of lack of repeatability and applicability of existing test methods. Lowrie, Garcia, and Henningson present an automated version of autogenous ignition equipment (G72) that reduces operator time for one test from 2 hours to 15 minutes. deQuay presents an analysis of mechanical impact test apparatuses and methods. McColskey, Reed, Simon, and Bransford recommend changes to mechanical impact tests ASTM D2512 and G86. These papers may provide the impetus to develop new standard test methods or to modify existing ones.

The second section, which addresses the ignition and combustion of nonmetallic materials, comprises three papers. de Richemond describes the results from laser-initiated combustion tests of several materials in oxygen-enriched environments. Sidebotham, Wolf, Stern, and Aftel discuss three flame types that relate to the combustion of endotracheal tubes. These two papers represent a relatively recent involvement by the G4 Committee in the subject of surgery-related fires. This is an important topic that should be addressed by the committee. Finally, Hirsch, Bunker, and Janoff present the results of a literature review regarding the effects of oxygen concentration, diluent gases, and pressure on ignition and flame-spread rates of nonmetals.

Eleven papers comprise the third section on ignition and combustion of metals. Simon, McColskey, Reed, and Gracia-Salcedo present test results on the compatibility of aluminum-lithium alloys and aluminum alloy 2219 with oxygen. Tack, McNamara, Stoltzfus, and Sircar discuss the effects of mechanical properties and composition on the compatibility of aluminum-lithium alloys with oxygen. Sircar, Stoltzfus, and Shelley relate the ignitibility and flammability of lead-tin alloys to their thermophysical and metallurgical properties. Reed, McCowan, McColskey and Simon discuss the definition of ignition due to mechanical-impact of aluminum alloys in oxygen. Zawierucha, McIlroy, and Mazzarella present data on the promoted ignition and combustion behavior of several Hastelloys and precipitation-hardened alloys in oxygen/nitrogen mixtures. Steinberg and Benz discuss the combustion of iron in oxygen in a microgravity environment. Sircar, Gabel, Benz, and Stoltzfus present a test method in which aluminum and titanium rods are weighed during combustion in oxygen. Stoltzfus, Lowrie, and Gunaji discuss the burn propagation behavior of wire mesh made from several alloys. Dunbobbin, Hansel, and Werley present additional data on the oxygen compatibility of high-surface-area metal alloys. These last two papers suggest that the results from oxygen compatibility tests on rods cannot be used reliably for ranking the suitability of materials in high surface-to-volume ratio configurations. An earlier version of the Dunbobbin, Hansel, and Werley paper was published in the January 1991 *Plant/Operations Progress* magazine (Vol. 10, No. 1, pp. 45-51). However, we decided to publish it in this volume because of its value to the G-4 community. The section concludes with a presentation by Schoenman and Franklin regarding the flame propagation rates of unalloyed beryllium and silicon-nitride in oxygen.

The fourth section presents four papers in which specific ignition mechanisms are analyzed. Reed, Simon, Berger, and McColskey present two papers in which they discuss the ignition mechanisms of aluminum alloys in the mechanical impact test. Leslie discusses a thermodynamic and fluid mechanic analysis of rapid pressurization in a dead-end tube. Finally, deQuay and Scheuermann make computer model predictions of reduction of hammer and adverse pressure effects in high-pressure, high-flow oxygen systems.

Materials selection is the subject of the five papers in the fifth section. Bryan, Stoltzfus, and Gunaji assess the metals flammability hazard in the Kennedy Space Center oxygen systems, and Nguyen and Pham assess the liquid-oxygen compatibility of aluminum-lithium alloys. de Monicault, Garceau, and Vagnard discuss the oxygen compatibility of materials and equipment for the Vulcain European rocket engine. Vagnard, Delode, and Barthelemy discuss the selection of nonmetallic materials for oxygen service and Barthelemy, Delode, and Vagnard compare rankings of relative oxygen compatibility of several materials obtained from different test methods.

The final section contains four papers on cleaning, centrifugal compressors, education, and test experience. Bryan, Carman, Schehl, and Underhill ask the question: Is "LOX clean" enough? Boddenberg and Waldmann discuss the special features in the construction of centrifugal compressors for oxygen service. Starr discusses the education and training of nonmedical users of emergency oxygen inhalators in the occupational setting. In the final paper, Schoenman, Sabiers, and McIlwain present test experience with a high-pressure oxygen turbopump and heat exchanger.

These papers confirm that the objectives of the Symposium were met. The papers presented here (in conjunction with previous symposia volumes) provide a previously unavailable reference of oxygen-system design concepts and practices. These volumes provide a data base that supports the use of ASTM Committee G-4 guides and standards. In addition, they serve as a guide to committee members in their future efforts to address the problems of safe oxygen use.

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