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# Standard Guide for Studying Fire Incidents in Oxygen Systems[1]

This standard is issued under the fixed designation G145; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide covers procedures and material for examining fires in oxygen systems for the purposes of identifying potential causes and preventing recurrence.

1.2 This guide is not comprehensive. The analysis of oxygen fire incidents is not a science, and definitive causes have not been established for some events.

1.3 The procedures and analyses in this guide have been found to be useful for interpreting fire events, for helping identify potential causes, and for excluding other potential causes. The inclusion or omission of any analytical strategy is not intended to suggest either applicability or inapplicability of that method in any actual incident study.

NOTE 1—Although this guide has been found applicable for assisting qualified technical personnel to analyze incidents, each incident is unique and must be approached as a unique event. Therefore, the selection of specific tactics and the sequence of application of those tactics must be conscious decisions of those studying the event.

NOTE 2—The incident may require the formation of a team to provide the necessary expertise and experience to conduct the study. The personnel analyzing an incident, or at least one member of the team, should know the process under study and the equipment installation.

1.4 **Warning—**During combustion, gases, vapors, aerosols, fumes, or combinations thereof, are evolved, which may be present and may be hazardous to people. *Caution*—Adequate precautions should be taken to protect those conducting a study.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

E620 Practice for Reporting Opinions of Scientific or Technical Experts
E678 Practice for Evaluation of Scientific or Technical Data (Withdrawn 2022)[3]
E860 Practice for Examining and Preparing Items That Are or May Become Involved in Criminal or Civil Litigation
E1020 Practice for Reporting Incidents that May Involve Criminal or Civil Litigation (Withdrawn 2022)[3]
E1138 Terminology for Technical Aspects of Products Liability Litigation (Withdrawn 1995)[3]
E1188 Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator
E1459 Guide for Physical Evidence Labeling and Related Documentation
E1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory
G63 Guide for Evaluating Nonmetallic Materials for Oxygen Service
G88 Guide for Designing Systems for Oxygen Service
G93 Guide for Cleanliness Levels and Cleaning Methods for Materials and Equipment Used in Oxygen-Enriched Environments
G94 Guide for Evaluating Metals for Oxygen Service
G114 Practices for Evaluating the Age Resistance of Polymeric Materials Used in Oxygen Service
G124 Test Method for Determining the Combustion Behavior of Metallic Materials in Oxygen-Enriched Atmospheres
G126 Terminology Relating to the Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres
G128 Guide for Control of Hazards and Risks in Oxygen Enriched Systems

[1] This guide is under the jurisdiction of ASTM Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres and is the direct responsibility of Subcommittee G04.02 on Recommended Practices.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

2.2 *Compressed Gas Association (CGA) Standards:*[4]

G-4.4 Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems

G-4.8 Safe Use of Aluminum Structured Packing for Oxygen Distillation

2.3 *National Fire Protection Association (NFPA) Standard:*[5]

NFPA 53 Fire Hazards in Oxygen Enriched Atmospheres

NFPA 921 Guide for Fire and Explosion Investigations

2.4 *Occupational Safety and Health Act:*[6]

OSHA Process Safety Management Compliance Manual

2.5 *ASTM Adjuncts:*

Video: Oxygen Safety[7]

## 3. Terminology

3.1 *Definitions*—See Guides G63, G94, and G128 for the terms listed in this section.

3.1.1 *oxygen compatibility, (also oxidant compatibility), n*—the ability of a substance to coexist with both oxygen and a potential source(s) of ignition at an expected pressure and temperature with a magnitude of risk acceptable to the user.

3.1.2 *qualified technical personnel, n*—persons such as engineers and chemists who, by virtue of education, training, or experience, know how to apply the physical and chemical principles involved in the reactions between oxygen and other materials.

3.1.3 *oxygen-enriched, adj*—a fluid (gas or liquid) mixture containing more than 25 mole % oxygen.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *incident, n*—an ignition or fire, or both, that is both undesired and unanticipated, or an undesired and unanticipated consequence of an ignition or fire that was anticipated.

3.2.2 *direct incident cause, n*—the mechanical or thermodynamic event (such as breakage of a component or near-adiabatic compression), the physicochemical property (such as heat of combustion), the procedure (such as a valve opening rate), or any departure(s) from the intended state of any of these items, that leads directly to ignition or fire, or both.

3.2.3 *fractional evaporation, n*—the continuous evaporation of a quantity of liquid that results in a progressive increase in the concentration of a less-volatile constituent(s).

3.2.4 *Contaminant, n*—unwanted molecular or particulate matter that could adversely affect or degrade the operation, life, or reliability of the systems or components upon which it resides.

3.2.5 *Contamination, n*—(1) the amount of unwanted molecular non-volatile residue (NVR) or particulate matter in a system; (2) the process or condition of being contaminated. Discussion—Contamination and cleanliness are opposing properties: increasing cleanliness implies decreasing contamination.

## 4. Summary of Guide

4.1 Following a fire incident in an oxygen-enriched atmosphere, the equipment, operating procedures, and area are considered in light of other incidents, potential contributing factors, suggested analytical strategies, and demonstrated laboratory results. The goal is to determine direct cause(s) of the incident in order to prevent a recurrence.

## 5. Significance and Use

5.1 This guide helps those studying oxygen system incidents to select a direct cause hypothesis and to avoid conclusions based on hypotheses, however plausible, that have proven faulty in the past.

## 6. Abstract

6.1 A series of possible causes and common scenarios are described to assist those seeking to understand incidents in oxygen-enriched atmospheres. Many easily misinterpreted factors are described to help avoid faulty conclusions. Several suspected but unproven incident scenarios are described. Select laboratory data are presented to support assertions about direct causes of incidents.

## 7. Direct-Cause Analysis

7.1 In this guide, the direct cause of an incident is the mechanical or thermodynamic event (such as breakage of a component or near-adiabatic compression), the physicochemical property (such as heat of combustion), the procedure (such as a valve opening rate), or any departure(s) from the intended state of any of these items, that leads directly to ignition or fire, or both. A fire might also be the result of a financial decision, worker skill, or manufacturing process—all of which can be viewed as causes—but such factors are addressed more properly in a system hazard review. It is noteworthy that some fires are anticipated and the risks (whether human or economic) are addressed by such things as shielding (for example, to control human risk) or acceptance (for example, to address economic risk). In these cases, a fire is not an "incident" unless some aspect of the event exceeded expectations the initial parameters (for example, the shielding did not provide the expected containment, or the cost exceeded projections). This guide seeks to identify the material choice, equipment design, assembly procedure, or other factor that led directly to the fire—and more specifically, to distinguish the physical object or action that caused the fire to start, to continue, or to be injurious or destructive. Remedial actions are found in other documents such as Guides G63, G88, and G94, and Practice G93, as well as NFPA 53, CGA G-4.4, and G-4.8, OSHA *Process Safety Management Compliance Manual*, and others.

7.2 *Example*—The direct cause of an incident may be concluded to be the use of an incompatible material, for example, a polyacetyl component was installed when a material such as PTFE (polytetrafluoroethylene) or CTFE (chlorotrifluoroethylene) was preferred. The direct cause was not that

[4] Available from Compressed Gas Association (CGA), 4221 Walney Rd., 5th Floor, Chantilly, VA 20151-2923, http://www.cganet.com.

[5] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[6] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[7] Available from ASTM Customer Service, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Request Adjunct ADJG0088.