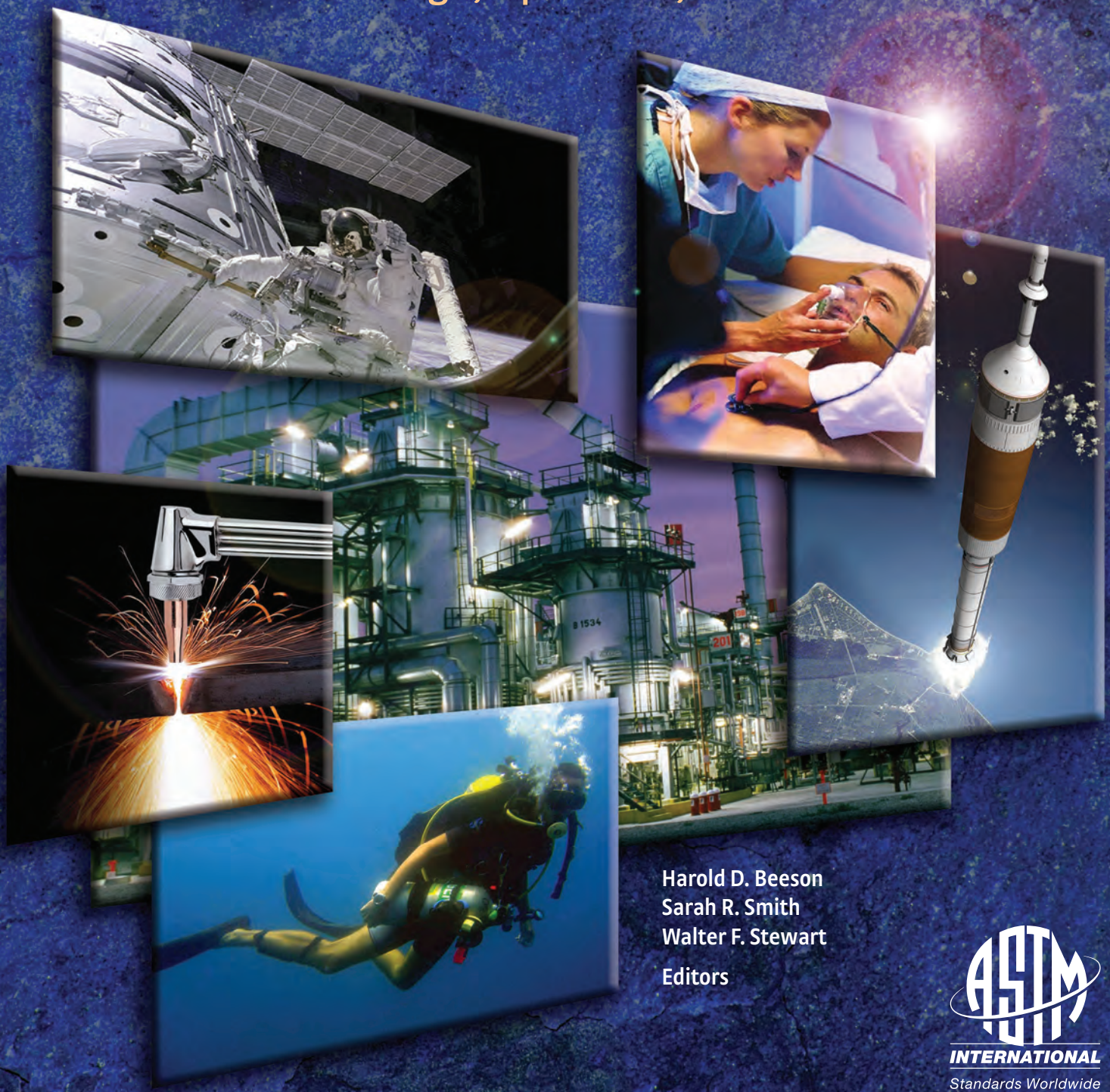
2nd Edition

Safe Use of Oxygen and Oxygen Systems:

Handbook for Design, Operation, and Maintenance



Harold D. Beeson
Sarah R. Smith
Walter F. Stewart
Editors

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First edition: Handbook for oxygen system design, operation, and maintenance

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Foreword

This edition of THE SAFE USE OF OXYGEN AND OXYGEN SYSTEMS is sponsored by Committee G4 on Compatibility and Sensitivity of Materials in Oxygen-Enriched Atmospheres. The editorial and review work for this edition were coordinated by Sarah R. Smith, NASA Johnson Space Center White Sands Test Facility, Las Cruces, New Mexico.

This edition of the handbook is an extensive revision of the original ASTM Manual 36. This revision includes large structural changes in the document as well as updates to the information and data contained herein.

This manual contains minimum guidelines; users are encouraged to assess their individual programs and develop additional requirements, as needed.

"Shalls" and "wills" denote requirements that are mandated by other existing documents, which are referenced.

Acknowledgments

The original material was contained in the *NASA Safety Standard for Oxygen and Oxygen Systems,* NSS 1740.15, which established a uniform NASA process for oxygen system design, materials selection, operation, storage, and transportation. The NASA document represented a wealth of information, knowledge, and experience gained by NASA and its contractors. This information, knowledge, and experience should be extremely valuable to industry, particularly the small or infrequent user of oxygen who has little or no experience and staff to draw upon.

The NASA Oxygen Safety Handbook was originally prepared under NASA contract by Paul M. Ordin, Consulting Engineer. The support of the NASA Hydrogen-Oxygen Safety Standards Review Committee in providing technical monitoring of the original standard is recognized. The Committee included the following members:

William J. Brown—NASA Lewis Research Center
Frank J. Benz—NASA Johnson Space Center
Mike Pedley—NASA Johnson Space Center
Dennis Griffin—NASA Marshall Space Flight Center
Coleman J. Bryan—NASA Kennedy Space Center
Wayne Thomas—NASA Lewis Research Center
Wayne Frazier—NASA Headquarters

The editors also gratefully acknowledge the special contributions of Grace B. Ordin for aiding the preliminary review, organizing the material, and editing the original drafts, and William A. Price of Vitro Corporation for input into the original standard. The NASA Oxygen Safety Handbook was prepared and edited by personnel at the NASA Johnson Space Center White Sands Test Facility. Specific contributors include: David Hirsch, Jan Goldberg, Elliot Forsyth, Mike Shoffstall, Mohan Gunaji, Rollin Christianson, Richard Shelley, Subhasish Sircar, Larry Bamford, Jim Williams, Jack Stradling, and Joel Stoltzfus. The expertise of these professionals in the area of oxygen system hazards, design, and operation is gratefully acknowledged.

The support of NASA Headquarters, Office of Safety and Mission Assurance, and specifically the support of Wayne Frazier and Claude Smith is gratefully acknowledged.

The sponsoring committee for this manual is ASTM G4 on Compatibility and Sensitivity of Materials in Oxygen-Enriched Atmospheres. The committee chairman is Joseph Slusser. The oxygen manual review taskgroup consisted of Alain Colson, Barry Newton, Bob Zawierucha, Eddie Davis, Elliot Forsyth, Herve Barthelemy, Jake Jacobs, Joe Million, Joe Slusser, Kim Dunleavy, Lee Birch, Mike Shoffstall, Michael Slockers, Gwenael Chiffoleau, John Somavarapu, Steve Herald, Joel Stoltzfus, and Ting Chou. The work of these individuals is gratefully acknowledged.

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Nomenclature

AAR	American Association of Railroads
AGA	American Gas Association
AHJ	Authority Having Jurisdiction
AIChE	American Institute of Chemical Engineers
AIHA	American Industrial Hygiene Association
AIT	Autoignition Temperature
Al_2O_3	Aluminum Oxide
ANSI	American National Standards Institute
API	American Petroleum Institute
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASRDI	Aerospace Safety Research and Data Institute
ASTM	American Society for Testing and Materials
BCL	Battelle Columbus Laboratories
BM	Bureau of Mines
CDR	Concept Design Review
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHEMTREC	Chemical Transportation Emergency Center
CNS	Central Nervous System
CP	Critical Point
CPIA	Chemical Propulsion Information Agency
Cr_2O_3	Chromium Oxide
CTFE	Chlorotrifluoroethylene
DCR	Design Certification Review
DI	Deionized
DOD	Department of Defense
DODESB	Department of Defense Explosives Safety Board
DOE	Department of Energy
DOT	Department of Transportation
ECTFE	Poly(chlorotrifluoroethylene-*co*-ethylene)
EIGA	European Industrial Gases Association
EPR	Emergency Procedures Review
ETFE	Poly(ethylene-*co*-tetrafluoroethylene)
FAA	Federal Aviation Administration
FDR	Final Design Review
FeO	Iron Oxide
FEP	Fluorinated Ethylene-propylene
FMEA	Failure Modes and Effects Analysis
FSA	Final Safety Analysis
GN_2	Gaseous Nitrogen
GOX	Gaseous Oxygen
HAZMAT	Hazardous Material
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFE	Hydrofluoroether
HMRB	Hazardous Materials Regulation Board
IEEE	Institute of Electrical and Electronic Engineering
IPA	Isopropyl Alcohol
ISO	International Organization for Standardization
LANL	Los Alamos National Laboratory
LH_2	Liquid Hydrogen
LNG	Liquified Natural Gas
LOI	Limiting Oxygen Index
LOX	Liquid Oxygen
MAPTIS	Materials and Processes Technical Information System
MAWP	Maximum Allowable Working Pressure
MCA	Manufacturers' Chemists Association
MCA	Materials Compatibility Assessment

M&P	Materials and Processes
MRHT	Marked Rated Holding Time
MSDS	Material Safety Data Sheet
MSFC	Marshall Space Flight Center
MSS	Manufacturers' Standardization Society
NASA	National Aeronautics and Space Administration
NBP	Normal Boiling Point
NBS	National Bureau of Standards (this organization is now the National Institute of Standards and Technology (NIST))
NEMA	National Electrical Manufacturers' Association
NER	Normal Evaporation Rate
NFPA	National Fire Protection Association
NHB	NASA Handbook
NiO	Nickel Oxide
NSS	NASA Safety Standard
NTIS	National Technical Information Service
NTP	Normal Temperature and Pressure (Absolute), 293.15 K (68°F) and 101.325 kPa (14.696 psi)
NTSB	National Transportation Safety Board
NVR	Nonvolatile Residue
OCA	Oxygen Compatibility Assessment
OHFRA	Oxygen Hazards and Fire Risk Assessment
OHM	Office of Hazardous Materials
OPR	Operating Procedures Review
ORI	Operational Readiness Inspection
ORR	Operational Readiness Review
OSHA	Occupational Safety and Health Administration
OTR	Operator Training Review
PDR	Preliminary Design Review
PHA	Preliminary Hazard Analysis
PICT	Promoted-Ignition Combustion Transition
PMMA	Polymethylmethacrylate
PSA	Preliminary Safety Analysis
PTFE	Polytetrafluoroethylene (Teflon®)
QA	Quality Assurance
RHT	Rated Holding Time
RP-1	Rocket Propellant-1 (Kerosene)
S&A	Safe and Arm
SAR	Safety Analysis Report
SAsR	Safety Assessment Review
SiO_2	Silicon Oxide
SOP	Standard Operating Procedure
SOW	Statement of Work
SR	Safety Review
SRM&QA	Safety, Reliability, Maintainability & Quality Assurance
SS	Stainless Steel
SSA	System Safety Analysis
SSA/SR	System Safety Analysis/Safety Review
SSPP	System Safety Program Plan
STP	Standard Temperature and Pressure (Absolute), 273.15 K (32°F) and 101.325 kPa (14.696 psi)
T_g	Glass Transition Temperature
TNT	Trinitrotoluene
TRR	Test Readiness Review
USCG	U.S. Coast Guard
WSTF	White Sands Test Facility
ZrO_2	Zirconium Oxide

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