Designation: C1554 – 18 (Reapproved 2023)

Standard Guide for Materials Handling Equipment for Hot Cells[1]

This standard is issued under the fixed designation C1554; 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 *Intent:*

1.1.1 This guide covers materials handling equipment used in hot cells (shielded cells) for the processing and handling of nuclear and radioactive materials. The intent of this guide is to aid in the selection and design of materials handling equipment for hot cells in order to minimize equipment failures and maximize the equipment utility.

1.1.2 It is intended that this guide record the principles and caveats that experience has shown to be essential to the design, fabrication, installation, maintenance, repair, replacement, and decontamination and decommissioning of materials handling equipment capable of meeting the stringent demands of operating, dependably and safely, in a hot cell environment where operator visibility is limited due to the radiation exposure hazards.

1.1.3 This guide may apply to materials handling equipment in other radioactive remotely operated facilities such as suited entry repair areas and canyons, but does not apply to materials handling equipment used in commercial power reactors.

1.1.4 This guide covers mechanical master-slave manipulators and electro-mechanical manipulators, but does not cover electro-hydraulic manipulators.

1.2 *Applicability:*

1.2.1 This guide is intended to be applicable to equipment used under one or more of the following conditions:

1.2.1.1 The materials handled or processed constitute a significant radiation hazard to man or to the environment.

1.2.1.2 The equipment will generally be used over a long-term life cycle (for example, in excess of two years), but equipment intended for use over a shorter life cycle is not excluded.

1.2.1.3 The equipment can neither be accessed directly for purposes of operation or maintenance, nor can the equipment be viewed directly, for example, without shielded viewing windows, periscopes, or a video monitoring system.

1.3 *User Caveats:*

1.3.1 This standard is not a substitute for applied engineering skills, proven practices and experience. Its purpose is to provide guidance.

1.3.1.1 The guidance set forth in this standard relating to design of equipment is intended only to alert designers and engineers to those features, conditions, and procedures that have been found necessary or highly desirable to the design, selection, operation and maintenance of reliable materials handling equipment for the subject service conditions.

1.3.1.2 The guidance set forth results from discoveries of conditions, practices, features, or lack of features that were found to be sources of operational or maintenance problems, or causes of failure.

1.3.2 This standard does not supersede federal or state regulations, or both, or codes applicable to equipment under any conditions.

1.3.3 This standard does not cover design features of the hot cell, for example, windows, drains, and shield plugs. This standard does not cover pneumatic or hydraulic systems. Refer to Guides C1533, C1217, and ANS Design Guides for Radioactive Material Handling Facilities & Equipment for information and references to design features of the hot cell and other hot cell equipment.

1.3.4 *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.*

1.4 *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 *Industry and National Consensus Standards*—Nationally recognized industry and consensus standards applicable in whole or in part to the design, fabrication, and installation of equipment are referenced throughout this guide and include, but are not limited to, the following:

[1] This guide is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.14 on Remote Systems.

Current edition approved Feb. 1, 2023. Published February 2023. Originally approved in 2003. Last previous edition approved in 2018 as C1554 – 18. DOI: 10.1520/C1554-18R23.

2.2 *ASTM Standards:*[2]

C859 Terminology Relating to Nuclear Materials

C1217 Guide for Design of Equipment for Processing Nuclear and Radioactive Materials

C1533 Guide for General Design Considerations for Hot Cell Equipment

C1572/C1572M Guide for Dry Lead Glass and Oil-Filled Lead Glass Radiation Shielding Window Components for Remotely Operated Facilities

C1615/C1615M Guide for Mechanical Drive Systems for Remote Operation in Hot Cell Facilities

C1661 Guide for Viewing Systems for Remotely Operated Facilities

2.3 *Other Standards:*

AAI A14.3 Ladders, Fixed Safety Requirements, OSHA[3]

ANS 8.1 Nuclear Criticality Safety in Operations with Fissile Materials Outside Reactors[4]

ANS Design Guides for Radioactive Material Handling Facilities & Equipment, ISBN: 0-89448-554-7[4]

ASSE SA/SAFE Ladders, Fixed Safety Requirements, OSHA[4]

ANSI B30.2 Overhead and Gantry Cranes[5]

ASME NQA 1 Quality Assurance Requirements for Nuclear Facility Applications[6]

ASME NOG-1 Rules for Construction of Overhead Gantry Cranes (Top-Running Bridge, Multiple Girder)[6]

ISO/TC 85/SC 2 N 637 E Remote Handling Devices for Radioactive Materials—Part 1 : General Requirements[7]

ISO 9001 Quality Management Systems Requirements[7]

NEMA 250 Enclosures for Electrical Equipment 1000 Volts Maximum (Type 4)[8]

NFPA 70 National Electric Code[9]

2.4 *Federal Regulations:*[10]

10CFR50 Appendix B, Quality Assurance

10CFR830.120 Nuclear Safety Management Quality Assurance Requirements

29CFR1910 Occupational Safety and Health Standards

40CFR 260-279 Solid Waste Regulations

3. Terminology

3.1 *Definitions:*

3.1.1 The terminology employed in this guide conforms with industry practice insofar as practicable.

3.1.2 For definitions of general terms used to describe hot cells and hot cell equipment, refer to Terminology C859, and Guide C1533.

3.1.3 *bogie*—a bogie is a small cart used to move material, supplies and small tools into, out of and within a hot cell.

3.1.4 *boot*—boot in this context refers to a flexible covering over equipment including a manipulator to protect it from radioactive contamination.

3.1.4.1 *Discussion*—The boot may also protect the equipment or manipulator from acid, caustic solutions and abrasive powders.

3.1.5 *Cartesian coordinate system*—a three-dimensional coordinate system in which the coordinates of a point in space are its distances from each of three intersecting, mutually perpendicular, planes along lines parallel to the intersection of the other two. Usually referred to as *X*, *Y*, and *Z*.

3.1.6 *coordinated control*—control of a manipulator that allows multiple axes of the manipulator to be automatically controlled to achieve a special motion of the wrist or end effector. These motions can be straight-line motion of the wrist or end effector, rotation about a point, movement in Cartesian coordinates or other motions at the wrist or end effector requiring relative motion of more than one joint.

3.1.7 *deadhead*—the act of placing a force on an immovable object or component.

3.1.8 *electro-hydraulic manipulator*—a manipulator in which each joint, either rotary or linear, of an electro-hydraulic manipulator is operated by a hydraulic motor or hydraulic cylinder. Control of the flow of hydraulic fluid to the hydraulic motors or cylinders to control position and speed are by electric-controlled servo valves. Electro-hydraulic manipulators are primarily used in under-sea environments and are generally not used in hot cells to date.

3.1.9 *end effector*—an end effector is a gripper or other device or tool on the end (wrist) of a slave of a master-slave or power manipulator.

3.1.10 *force ball*—a force ball is an input device in the shape of a sphere that provides signals relative to force or torques, or both, placed on the ball by an operator. The signals are usually segregated into forces and torques in different directions, usually Cartesian, even though the operator input is generally in a combination of directions.

3.1.11 *force feedback*—force feedback is an electrical signal relative to force sensed, usually at a joint of a manipulator. Force feedback is commonly used to generate a force at the master that is relative to the sensed force on the end effector.

3.1.12 *force reflection*—force reflection is the perception of force at the master of a master-slave manipulator that is relative to the forces applied at the end effector.

3.1.13 *hot cell, n*—an isolated, shielded containment that provides a controlled environment and is designed to safely

[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] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

[4] Available from American Nuclear Society, 555 North Kensington Ave., La Grange Park, IL 60525, (312) 352-6611.

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[6] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[7] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[8] Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704, http://www.global.ihs.com.

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

[10] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.