Designation: C1533 – 15 (Reapproved 2022)

Standard Guide for General Design Considerations for Hot Cell Equipment[1]

This standard is issued under the fixed designation C1533; 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 The intent of this guide is to provide general design and operating considerations for the safe and dependable operation of remotely operated hot cell equipment. Hot cell equipment is hardware used to handle, process, or analyze nuclear or radioactive material in a shielded room. The equipment is placed behind radiation shield walls and cannot be directly accessed by the operators or by maintenance personnel because of the radiation exposure hazards. Therefore, the equipment is operated remotely, either with or without the aid of viewing.

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

1.1.3 This guide does not apply to equipment used in gloveboxes.

1.2 *Applicability:*

1.2.1 This guide is intended for persons who are tasked with the planning, design, procurement, fabrication, installation, or testing of equipment used in remote hot cell environments.

1.2.2 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.

1.2.3 The system of units employed in this standard is the metric unit, also known as SI Units, which are commonly used for International Systems, and defined by IEEE/ASTM SI 10: American National Standard for Use of the International System of Units (SI): The Modern Metric System.

1.3 *Caveats:*

1.3.1 This guide does not address considerations relating to the design, construction, operation, or safety of hot cells, caves, canyons, or other similar remote facilities. This guide deals only with equipment intended for use in hot cells.

1.3.2 Specific design and operating considerations are found in other ASTM documents.

1.4 *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.*

1.5 *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]

A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

A240/A240M Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

A276 Specification for Stainless Steel Bars and Shapes

A320/A320M Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service

A354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners

A479/A479M Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels

A489 Specification for Carbon Steel Eyebolts

A490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength (Withdrawn 2016)[3]

C859 Terminology Relating to Nuclear Materials

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

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

[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 July 1, 2022. Published July 2022. Originally approved in 2002. Last previous edition approved in 2015 as C1533 – 15. DOI: 10.1520/C1533-15R22.

[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.

C1615 Guide for Mechanical Drive Systems for Remote Operation in Hot Cell Facilities
C1661 Guide for Viewing Systems for Remotely Operated Facilities
C1725 Guide for Hot Cell Specialized Support Equipment and Tools
D676 Method of Test for Indentation of Rubber by Means of a Durometer; Replaced by D 2240 (Withdrawn 1964)[3]
D5144 Guide for Use of Protective Coating Standards in Nuclear Power Plants
F593 Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

2.2 *Other Standards:*
10CFR830.120 Nuclear Safety Management Quality Assurance Requirements[4]
ANSI/ANS-8.1 Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors[5]
ANSI/ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications[6]
ANSI/ISO/ASQ 9001 Quality Management Systems[5]
ASME Y14.5 Dimensioning and Tolerancing[6]
ICRU Report 10b Physical Aspects of Irradiation[7]
NCRP Report No. 82 SI Units in radiation Protection and Measurements[8]

3. Terminology

3.1 The terminology employed in this guide conforms to industry practice insofar as practicable.

3.2 For definitions of terms not described in this guide, refer to Terminology C859.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *canyon*—a long narrow, remotely operated and maintained radiological area within a facility where nuclear material is processed or stored.

3.3.2 *cave*—typically a small-scale hot cell facility, but is sometimes used synonymously with hot cell.

3.3.3 *dose equivalent*—the measure of radiation dose from all types of radiation expressed on a common scale. The specialized unit for dose equivalent is the rem. The SI unit for dose equivalent is the sievert (Sv), which is equal to 100 rem. Human exposure is often expressed in terms of microsieverts (μSv), 1×10^{-6} sieverts, or in terms of millirem (mrem), 1×10^{-3}.

3.3.4 *electro-mechanical manipulator (E/M)*—usually mounted on a crane bridge, wall, pedestal, or ceiling and is used to handle heavy equipment in a hot cell. Each joint of the E/M is operated by an electric motor or electric actuator. The E/M is operated remotely using controls from the uncontaminated side of the hot cell. Most E/Ms have lifting capacities of 100 lb or more.

3.3.5 *gamma radiation*—high energy, short wavelength electromagnetic radiation which normally accompanies the other forms of particle emissions during radioactive decay. Gamma radiation has no electrical charge.

3.3.6 *high density concrete*—a concrete having a density of greater than 2400 kg/m^3 (150 lb/ft^3).

3.3.7 *hot cell*—an isolated shielded room that provides a controlled environment for containing highly radioactive and contaminated material and equipment. The radiation levels within a hot cell are typically 1 Gy/h (100 rads per hour) or higher in air.

3.3.8 *master-slave manipulator (MSM)*—a device used to handle items, tools, or radioactive material in a hot cell. The in-cell or slave portion of the manipulator replicates the actions of an operator outside of the hot cell by means of a through-wall mechanical connection between the two, usually with metal tapes or cables. MSMs have lifting capacities of 9 kg to 23 kg (20 lb to 50 lb).

3.3.9 *mock-up*—a facility used to represent the physical environment of a radiological facility in a non-radiological setting. Mock-ups are full scale facilities used to assure proper clearances, accessibility, visibility, or operability of items to be subsequently installed in a radiological environment.

3.3.10 *radiation absorbed dose (rad)*—radiation absorbed dose is the quotient of the mean energy imparted by ionizing radiation to matter of mass. The SI unit for absorbed dose is the gray (NCRP Report No. 82).

3.3.11 *radiation streaming*—unshielded beams of radiation.

3.3.12 *roentgen equivalent man (rem)*—a measure of the damaging effects of ionizing radiation to man. See *dose equivalent* (NCRP Report No. 82, ICRU Report 10b).

4. Significance and Use

4.1 The purpose of this guide is to provide general guidelines for the design and operation of hot cell equipment to ensure longevity and reliability throughout the period of service.

4.2 It is intended that this guide record the general conditions and practices that experience has shown is necessary to minimize equipment failures and maximize the effectiveness and utility of hot cell equipment. It is also intended to alert designers to those features that are highly desirable for the selection of equipment that has proven reliable in high radiation environments.

[4] 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.
[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 Commission on Radiation Units and Measurements, Inc., 7910 Woodmont Ave., Suite 400, Bethesda, MD 20814-3095, http://www.icru.org.
[8] Available from National Council of Radiation Protection and Measurements, 7910 Woodmont Ave., Suite 400, Bethesda, MD 20814-3095, http://www.ncrponline.org.