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Standard Guide for Viewing Systems for Remotely Operated Facilities¹

This standard is issued under the fixed designation C1661; 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 establishes the minimum requirements for viewing systems for remotely operated facilities, including hot cells (shielded cells), used for the processing and handling of nuclear and radioactive materials. The intent of this guide is to aid in the design, selection, installation, modification, fabrication, and quality assurance of remote viewing systems to maximize their usefulness and to minimize equipment failures.

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 remote viewing 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 is intended to apply to methods of remote viewing for nuclear applications but may be applicable to any environment where remote operational viewing is desirable.

1.2 Applicability:

1.2.1 This guide applies to, but is not limited to, radiation hardened and non-radiation hardened cameras (black-and-white and color), lenses, camera housings and positioners, periscopes, through wall/roof viewing, remotely deployable cameras, crane/robot mounted cameras, endoscope cameras, borescopes, video probes, flexible probes, mirrors, lighting, fiber lighting, and support equipment.

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

1.2.2.1 The remote operation facility that contains a significant radiation hazard to man or the environment.

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

1.2.2.3 The facility can be viewed directly but portions of the views are restricted (for example, the back or underside of objects) or where higher magnification or specialized viewing is beneficial.

1.2.3 The remote viewing equipment may be intended for either long-term application (commonly, in excess of several years) or for short-term usage (for example, troubleshooting). Both types of applications are addressed in sections that follow.

1.2.4 This guide is not intended to cover the detailed design and application of remote handling connectors for services (for example, electrical, instrumentation, video, etc.).

1.2.5 The system of units employed in this guide is the metric unit, also known as SI Units, which are commonly used for International Systems, and defined by [ASTM/IEEE SI 10](#), Standard for Use of International System of Units. Some video parameters use traditional units that are not consistent with SI Units but are used widely across the industry. For example, video image format is referred to in “inch” units. (See Table 1.)

1.2.6 Lens and lens element measurements are always in millimeter (mm) units, even where SI Units are not in common usage, as an industry practice. Other SI Units (for example, cm) are rarely used for lenses or lens elements.

1.2.7 Unless otherwise mentioned in this guide radiation exposure refers to gamma energy level in terms of ⁶⁰Co exposure, and absorbed radiation dose Gy/h (rad/h) refers to instantaneous rates and not cumulative values.

1.3 User Caveats:

1.3.1 This guide does not cover radiation shielding windows used for hot cell viewing. They are covered separately under Guide [C1572/C1572M](#).

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

1.3.3 The guidance set forth in this guide relating to design of equipment is intended only to inform designers and engineers of these features, conditions, and procedures that have been found necessary or highly desirable to the design, selection, operation and maintenance of reliable remote viewing equipment for the subject service conditions.

1.3.4 The guidance set forth in this guide results from operational experience of conditions, practices, features, lack of features, or lessons learned that were found to be sources of operating or maintenance problems, or causes of failure.

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.

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1.3.5 This guide does not supersede federal or state regulations, or codes applicable to equipment under any conditions.

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

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
 - C1554 Guide for Materials Handling Equipment for Hot Cells
 - C1572/C1572M Guide for Dry Lead Glass and Oil-Filled Lead Glass Radiation Shielding Window Components for Remotely Operated Facilities
 - E170 Terminology Relating to Radiation Measurements and Dosimetry
 - ASTM/IEEE SI 10 Standard for Use of the International System of Units
- ### 2.3 Other Standards:
- ANS 8.1 Nuclear Criticality Safety in Operations with Fissile Materials Outside Reactors³
 - ANS Design Guides for Radioactive Material Handling Facilities & Equipment, ISBN: 0-89448-554-7³
 - ANS Glossary of Terms in Nuclear Science and Technology (ANS Glossary)³
 - ANSI/ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications⁴
 - ISO/TC 85/SC 2 N 637 E Remote Handling Devices for Radioactive Materials—Part 1⁵

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 American Nuclear Society, 555 North Kensington Ave., La Grange Park, IL, 60525.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁵ Available from International Organization for Standardization (ISO), 1 rue de Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland, <http://www.iso.ch>.

ANSI/ISO/ASQ Q9001 Quality Management Standard Requirements General Requirements⁶

NEMA 250 Enclosures for Electrical Equipment 1000 Volts Maximum (Type 4)⁷

NFPA 70 National Electric Code⁸

NCRP Report No. 82 SI Units in Radiation Protection and Measurements⁹

ICRU Report 10b Physical Aspects of Irradiation¹⁰

2.4 Federal Standards and Regulations:¹¹

10CFR50 Appendix B, Quality Assurance

10CFR830.120 Quality Assurance for Nuclear Facilities

10CFR835.1002(b) Continuous Occupancy Radiation Environments

29CFR1910 Occupational Safety and Health Standards

47CFR All Parts—Telecommunications Regulations

40CFR 260-279 Solid Waste Regulations—Resource Conservation and Recovery Act (RCRA)

15CFR, Chapter VII, Subchapter C, Part 774, Supplement 1, Department Of Commerce, Export Administration Regulations

3. Terminology

3.1 Definitions—General Considerations:

3.1.1 For definitions of general terms used to describe nuclear material hot cells, and hot cell equipment, refer to terminology in Guides C859 and C1533, ASTM/IEEE SI 10, and ANS Glossary of Terms in Nuclear Science and Technology.

3.2 Definitions:

3.2.1 *achromat*—lens, usually of two elements, that is corrected to bring two different wavelengths to a common focal point; a single element lens can only bring one wavelength to a focal point and therefore exhibits chromatic aberration (different wavelengths focus at different distances); an achromatic lens provides a first order of color correction.

3.2.2 *activity, A, [T⁻¹]*, *n*—measure of the rate of spontaneous nuclear transformations of a radioactive material; the SI unit for activity is the becquerel (Bq), defined as one transformation per second; the original unit for activity was the curie (Ci), defined as 3.7×10^{10} transformations per second.

NCRP-82

3.2.3 *balun*—for the purpose of this guide, type of passive electronic equipment (that is, not requiring power) that is used to interface between balanced and unbalanced video signals; baluns are used to transition between a coaxial cable and

⁶ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁷ Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704, <http://global.ihs.com>.

⁸ Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

⁹ Available from National Council of Radiation Protection and Measurements, 7910 Woodmont Avenue, Suite 400, Bethesda, MD, 20814-3095.

¹⁰ Available from International Commission on Radiation Units and Measurements (ICRU), 7910 Woodmont Ave., Suite 400, Bethesda, MD 20841-3095, <http://www.icru.org>.

¹¹ 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>.