Designation: C1572 – 10

Standard Guide for Dry Lead Glass and Oil-Filled Lead Glass Radiation Shielding Window Components for Remotely Operated Facilities[1]

This standard is issued under the fixed designation C1572; 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 standard is to provide guidance for the design, fabrication, quality assurance, inspection, testing, packaging, shipping, installation, and maintenance of radiation shielding window components. These window components include wall liner embedments, dry lead glass radiation shielding window assemblies, oil-filled lead glass radiation shielding window assemblies, shielding wall plugs, barrier shields, view ports, and the installation/extraction table/device required for the installation and removal of the window components.

1.2 *Applicability:*

1.2.1 This standard is intended for those persons who are tasked with the planning, design, procurement, fabrication, installation, and operation of the radiation shielding window components that may be used in the operation of hot cells, high level caves, mini-cells, canyon facilities, and very high level radiation areas.

1.2.2 This standard applies to radiation shielding window assemblies used in normal concrete walls, high-density concrete walls, steel walls and lead walls.

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 ASTM/IEEE SI-10 Standard for Use of International System of Units. Common nomenclature for specifying some terms; specifically shielding, uses a combination of metric units and inch-pound units.

1.2.4 This standard identifies the special information required by the Manufacturer for the design of window components. A1.1 shows a sample list of the radiation source spectra and geometry information, typically required for shielding analysis. A2.1 shows a detailed sample list of specific data typically required to determine the physical size, glass types, and viewing characteristics of the shielding window, or view port. A3 shows general window configuration sketches. Blank copies of A1.2 and A2.2 are found in the respective Annexes for the Owner–Operator's use.

1.2.5 This standard is intended to be generic and to apply to a wide range of configurations and types of lead glass radiation shielding window components used in hot cells. It does not address glovebox, water, X-ray glass, or zinc bromide windows.

1.2.6 Supplementary information on viewing systems in hot cells may be found in Guides C1533 and C1661.

1.3 *Caveats:*

1.3.1 Consideration shall be given when preparing the shielding window designs for the safety related issues discussed in the Hazard Sources and Failure Modes, Section 11; such as dielectric discharge, over-pressurization, radiation exposure, contamination, and overturning of the installation/extraction table/device.

1.3.2 In many cases, the use of the word "shall" has been purposely used in lieu of "should" to stress the importance of the statements that have been made in this standard.

1.3.3 *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 and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *Industry and National Consensus Standards*—Nationally recognized industry and consensus standards which may be applicable in whole or in part to the design, fabrication, quality assurance, inspection, testing, packaging, shipping, installation and maintenance of radiation shielding window components are referenced throughout this standard and include the following:

2.2 *ASTM Standards:*[2]

A27/A27M Specification for Steel Castings, Carbon, for General Application

[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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[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.

A36/A36M Specification for Carbon Structural Steel
A48/A48M Specification for Gray Iron Castings
A240/A240M Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
A747/A747M Specification for Steel Castings, Stainless, Precipitation Hardening
C1533 Guide for General Design Considerations for Hot Cell Equipment
C1661 Guide for Viewing Systems for Remotely Operated Facilities
D1533 Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration
E165 Practice for Liquid Penetrant Examination for General Industry
E170 Terminology Relating to Radiation Measurements and Dosimetry
E2024 Test Methods for Atmospheric Leaks Using a Thermal Conductivity Leak Detector
ASTM/IEEE SI-10 Standard for Use of the International System of Units

2.3 *American Concrete Institute (ACI) Standards:*[3]
ACI C-31 Seismic Requirements

2.4 *American Institute of Steel Construction (AISC) Standard:*[4]
Manual of Steel Construction

2.5 *American National Standards Institute (ANSI) Standards:*[5]
ANSI Y 14 Engineering Drawing and Related Documentation Practices
ANSI/ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications
ANSI/AWS A2.4 Standard Symbols for Welding, Brazing and Nondestructive Examination
ANSI/AWS B2.1 Specification for Welding Procedure and Performance Qualification
ANSI/AWS D1.1/D1.1M Structural Welding Code—Steel
ANSI/AWS D1.6/D1.6M Structural Welding Code—Stainless Steel
ANSI/ISO/ASQ 9001 Quality Management Standard Requirements

2.6 *American Society for Nondestructive Testing (ASNT) Standards:*[6]
ASNT-SNT-TC-1A Recommended Practice for Qualification and Certification of Nondestructive Testing

2.7 *Steel Structures Painting Council (SSPC):*[7]
SSPC-SP1 Solvent Cleaning
SSPC-SP6 Commercial Blast Cleaning
SSPC-P1 Paint Application Specification

2.8 *Federal Standards (FS):*[8]
QQ-C-40 Caulking, Lead Wool, and Lead Pig

2.9 *Federal Regulations (FR):*[8]
10 CFR20.1003 Definitions
10 CFR50, Appendix B Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants
10 CFR830.120 Subpart A Nuclear Safety Management, Quality Assurance Requirements

2.10 *International Building Code (IBC):*[8]
IBC Section 2314 Earthquake Regulations

2.11 *Other Standards:*
AESS (R) 44/70000/6 Atomic Energy Standard Specification for Shielding Glass[9]
NCRP Report No. 82 SI Units in Radiation Protection and Measurements[10]
ICRU Report 10b Physical Aspects of Irradiation[11]

3. Terminology

3.1 *Definitions:*

3.1.1 *absorbed dose, D, [L^2T^2], n*—absorbed dose is the mean energy imparted by ionizing radiation to a mass of specified material.

3.1.1.1 *Discussion*—The SI unit for absorbed dose is the gray (Gy), defined as 1J/kg. **NCRP-82**

3.1.2 *activity, A, [T^1], n— in the nuclear industry*, the measure of the rate of spontaneous nuclear transformations of a radioactive material.

3.1.2.1 *Discussion*—The SI unit for activity is the becquerel (Bq), defined as 1 transformation per second.

3.1.2.2 *Discussion*—The original unit for activity was the curie (Ci), defined as 3.7×10^{10} transformations per second. **NCRP-82**

3.1.3 *air dryer cartridge, n*—a cloth bag containing moisture-absorbent crystals.

3.1.3.1 *Discussion*—The bag is inserted into the dryer assembly. The crystals are used to absorb moisture from the contained environment.

3.1.4 *alpha radiation, n*—the spontaneous emission of an alpha particle, composed of two protons and two neutrons with a positive charge of plus two, during the nuclear transformation process.

3.1.4.1 *Discussion*—An alpha particle is the same as a helium atom with no electrons.

3.1.5 *anti-reflection treatment, n*—a process applied to the surface of the glass that reduces reflection and increases the light transmission through the glass.

3.1.5.1 *Discussion*—It is often called a low-reflection treatment.

[3] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org.
[4] Available from American Institute of Steel Construction (AISC), One E. Wacker Dr., Suite 700, Chicago, IL 60601-2001, http://www.aisc.org.
[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 for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.
[7] Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, http://www.sspc.org.
[8] 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.
[9] HMSO, St. Clements House, 2-16 Colegate, Norwich, NR3 1BQ. UK.
[10] Available from National Council of Radiation Protection and Measurements, 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814-3095.
[11] Available from International Commission on Radiation Units and Measurements, Inc., 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814-3095.

3.1.6 *as-built drawings, n*—a set of drawings that reflect all of the changes that were incorporated into the components during the manufacturing process since the original design.

3.1.7 *barrier shield assembly, n*—consists of steel frames, gaskets, and a glass plate; typically cerium-stabilized, assembled together to form a see through barrier.

3.1.7.1 *Discussion*—The assembly is mechanically fastened to the hot side of the wall liner to provide a gas tight containment barrier, which protects the window assembly from any radioactive contamination within the hot cell (alpha particles and other contaminates).

3.1.8 *barrier shield glass, n*—a glass plate; typically cerium stabilized that is used as a cover glass to see through and isolate the window assembly from contamination.

3.1.8.1 *Discussion*—It is normally mounted in a barrier shield frame with gaskets to make up a barrier shield assembly.

3.1.9 *becquerel (Bq), [T^1], n*—the SI unit of measure for activity, defined as one transformation per second.

3.1.10 *bellows, n*—a flexible enclosure generally made of a pliable gasket material, which expands and contracts with the temperature change of the inert gas and other components, maintaining a controlled atmosphere within the window assembly.

3.1.10.1 *Discussion*—When employed, the bellows is generally connected to the top of the expansion tank on an oil-filled window, and directly above the air dryer on the window housing of a dry window. The material of selection must be compatible with the environment, and with the window components.

3.1.11 *beta radiation, n*—an electron that was generated in the atomic nucleus during decay and has a negative charge of one.

3.1.12 *browning, n*—the discoloration and darkening of glass to a brownish color due to excessive radiation exposure.

3.1.13 *bubbler system, n*—a device used as a pressure relief, and constructed of an outer open top container or chamber that is filled with a liquid.

3.1.13.1 *Discussion*—It has a separate pressurized tube inserted into the liquid. When over-pressurization occurs in the tube, the gas bubbles out the bottom of the tube and up to the surface through the liquid.

3.1.14 *buffer seal, n*—a specially configured seal gasket used on a barrier shield.

3.1.15 *build-up factor, n*—for radiation passing through a medium, buildup factor is the ratio of the total value of a specific radiation quantity (direct and scattered) measured as absorbed dose at any point within that medium to the contribution to that quantity from the incident uncollided radiation reaching that point.

3.1.15.1 *Discussion*—The build-up factor increases with increased shielding thickness and is higher for low atomic number materials.

3.1.16 *canyon, n—in the nuclear industry*, a long, narrow, remotely operated radiological facility.

3.1.16.1 *Discussion*—A large, heavily-shielded facility where nuclear material is processed or stored.

3.1.17 *cave, n—in the nuclear hot cell applications*, typically a small-scale hot cell facility.

3.1.17.1 *Discussion*—This term is sometimes used synonymously with hot cell.

3.1.18 *central viewing area, [L^2], n*—the central viewing area of a glass slab or glass plate is that viewing area, circular or elliptical, of which the diameter of axis is 80 % of the maximum usable viewing window dimensions.

3.1.19 *cerium-stabilized glass, n*—a glass type that contains a small percentage of cerium oxide to help stabilize the glass from discoloration due to radiation exposure.

3.1.19.1 *Discussion*—It is often called non-browning glass.

3.1.20 *CMTR, n*—the abbreviation for a Certified Material Test Report, which is a document that certifies the results of tests and analyses performed on the item provided.

3.1.21 *checks, n*—very small fractures, or breakouts, normally around the edge of a glass plate or glass slab.

3.1.22 *chip, n*—a fragment broken from an edge or surface.

3.1.23 *clear view, [L^2], n*—the physical size (length × width) of the smallest glass slab of all the glass components in a shielding window assembly.

3.1.23.1 *Discussion*—The actual clear view may be reduced by the method of retention of the glass in the window.

3.1.24 *cold side, n*—the surface on a radiation shielding window that is farthest from the radioactive source, and usually is not subject to contamination.

3.1.25 *cold side load, n*—a cold side load window assembly is an assembly that is inserted into a wall liner or removed from a wall liner from the operator (cold side) of the hot cell.

3.1.26 *cover glass (hot or cold side), n*—a glass plate positioned on the hot or cold side of the window.

3.1.26.1 *Discussion*—The cover glass is often held in place with a trim frame assembly and seal gaskets. This assembly achieves a seal, which isolates the inner glass slabs from the external atmosphere and may also hold or contain the mineral oil within the window assembly.

3.1.27 *curie (Ci), [T^1], n*—the original unit of measure for activity, defined as 3.7×10^{10} transformations per second.

3.1.28 *density inch, n*—a term used to describe the specific gravity of a shielding material multiplied by the thickness of that material in inches. The units are g/cc × (in.).

3.1.29 *desiccant air dryer, n*—a device filled with crystals and is used to remove moisture from a contained environment.

3.1.30 *dielectric discharge, n*—an instantaneous flow of electrical current from an irradiated glass component to the ground, causing severe damage to the glass, usually in the form of a dendritic fracture (Lichtenberg Figure) or heavy cleavage.

3.1.31 *dose equivalent, [L^2 T^2], n*—a measure of the biological effects of radiation dose from all types of radiation expressed on a common scale.

3.1.31.1 *Discussion*—The SI unit for dose equivalent is the sievert (Sv), which is equal to 100 rem (specialized unit for human dose equivalent). Radiation dose equivalent is often expressed in terms of microsieverts (µSv) or millirem (mrem).

3.1.32 *dose rate, [L^2 T^3], n*—a quantity of absorbed dose received in a given unit of time.

3.1.33 *dry lead glass window, n*—a radiation shielding window that is filled with slabs of lead glass with polished glass surfaces.

3.1.33.1 *Discussion*—The assembly may be continuously purged with an inert gas. The glass surfaces within the shielding window assembly are normally treated to minimize surface reflection.

3.1.34 *duty cycle, [T], n*—is a factor considered in the design of window life based on anticipated cell usage.

3.1.34.1 *Discussion*—It is dose rate versus time at a particular location.

3.1.35 *electro-mechanical manipulator (E/M), n*—a remotely operated handling and lifting device used to manipulate equipment in a hot cell that is to heavy to handle with MSMs.

3.1.35.1 *Discussion*—Each joint of the E/M is operated by an electric motor or electric actuator. The manipulator can be mounted on a crane bridge, wall, pedestal, or ceiling.

3.1.36 *exposure, [M^1 TI], n— in X-ray and gamma radiation*, radiation exposure is a measure of the amount of ionization produced by X-ray or gamma rays as they travel through air.

3.1.36.1 *Discussion*—The special unit of radiation exposure is the roentgen (R). It is equivalent to 2.58×10^{-4} coulombs per kilogram of air.

3.1.37 *extreme view angle, n*—the maximum angle that an operator can see into the hot cell when looking through the shielding window from the extreme perimeter edge of the cold side trim frame.

3.1.38 *gamma radiation, n*—high-energy, short-wavelength electromagnetic radiation which originates from the atomic nucleus.

3.1.38.1 *Discussion*—Gamma radiation often accompanies particle emissions associated with radioactive decay. Gamma radiation has no electrical charge.

3.1.39 *gas purge line, n*—a stainless steel tube supplying a pressurized gas to the window assembly.

3.1.40 *gas-tight seal, n*—a seal that meets the requirements of a leak rate test.

3.1.41 *gas vent line, n*—a stainless steel tube connected to the window assembly for the purpose of venting gas.

3.1.42 *glass plate, n*—typically used as cover glasses or barrier shields.

3.1.42.1 *Discussion*—The maximum thickness is typically 40 mm (1.5 in.) thick.

3.1.43 *glass slabs, n*—typically used for internal shielding in windows and view ports.

3.1.43.1 *Discussion*—The typical thickness ranges from a minimum of 40 mm (1.5 in.) up to a maximum of 400 mm (16 in.) thick.

3.1.44 *glass surface defects, n*—refer to those defects that are on the glass surface and can be removed by reprocessing or repolishing the glass surface.

3.1.44.1 *Discussion*—These defects are scratches, short finish, and stripping.

3.1.45 *gray (Gy), [L^2 T^2], n*—a gray is the SI unit of absorbed dose (1 J/kg).

3.1.46 *high density concrete, n*—a concrete having a weight of greater than 2400 kg per cubic metre (150 lb per cubic foot).

3.1.47 *high level caves, n*—a small-scale hot cell facility.

3.1.48 *hot cell, n*—an isolated shielded containment that provides a controlled environment and is designed to safely handle radioactive and typically contaminated material and equipment.

3.1.48.1 *Discussion*—The design radiation levels within a hot cell are typically 1 Gy/h (100 rads per hr) or higher.

3.1.49 *hot side, n*—the surface on a radiation shielding window that, when installed, will be the closest to the radioactive sources.

3.1.50 *inclusions, n*—"small bubbles," "small black stones," and "seeds" that are visible in optical quality glass.

3.1.51 *inert gas, n*—a type of commercial-grade, moisture-free gas.

3.1.51.1 *Discussion*—The gas is usually argon or nitrogen that is purged into the internal window assembly to displace ambient air.

3.1.52 *installation/extraction table/device, n*—a heavy duty table or device capable of supporting one and one-half times the shielding window's weight that is used for extracting a shielding window, shielding plug, or view port from an embedment wall liner, or installing the shielding window, shielding plug, or view port into the wall liner.

3.1.53 *lead packing, n*—lead material in the form of a wool mesh or sheet material positioned inside a window assembly housing to fill the voids between the edges of the glass slabs and the window housing.

3.1.53.1 *Discussion*—The packing is required to provide shielding equivalence to the glass components within the window assembly and the hot cell wall, and to eliminate radiation "shine" paths.

3.1.54 *light transmission, n*—the measurement of light transmitted through a media and is specified as a ratio of light transmitted through the media as compared to the light transmitted through air.

3.1.55 *master-slave manipulator (MSM), n*—a type of device to remotely handle items, tools, or radioactive material in a hot cell.

3.1.55.1 *Discussion*—The operator controls the master and the follower, or "slave," replicates its movements to handle the material in the hot cell. The mechanical connection between the master and the follower is made with metal tapes or cables. MSMs typically have lifting capacities of 9 to 23 kg (20 to 50 lb).

3.1.56 *mini-cell, n*—a very small, hot cell.

3.1.57 *NCR, n*—the abbreviation for a Manufacturer's Non-Conformance Report.

3.1.57.1 *Discussion*—This quality assurance report is generated when an item does not meet specification and must state the manufacturer's proposed course of action and how the solution deviates from the contract.

3.1.58 *neutron radiation, n*—the emission of neutrons from the atomic nucleus.

3.1.58.1 *Discussion*—Neutrons have an atomic mass slightly heavier than a proton, but have no electrical charge.

3.1.59 *non-browning glass, n*—a glass type that resists discoloration due to high radiation exposure.

3.1.60 *normal concrete, n*—a concrete mixture that has a weight of between 2250 and 2400 kg per m^3 (140 to 150 lb/ft^3).

3.1.61 *normal view angle, n*—the angle of view the operator can see into the hot cell when looking through the shielding window at the operator's eye level at a given distance from the cold side cover glass.

3.1.62 *oil expansion tank, n*—a stainless steel or glass tank attached to the cold side hot cell wall which allows for volumetric changes of the oil within the window due to temperature changes.

3.1.62.1 *Discussion*—Stainless steel is the preferred type. The oil supply in the window is connected to the expansion tank.

3.1.63 *oil-filled lead glass window, n*—a lead glass radiation shielding window filled with an optical grade shielding oil.

3.1.64 *polished glass surface, n*—a glass surface that has been polished and has minimal visual defects such as scratches and short finish.

3.1.65 *rad* $[L^2\ T^2]$, *n*—a unit of measure of radiation absorbed dose. See *absorbed dose*.

3.1.66 *radiation, n—in the nuclear industry*, the emission that occurs when a nucleus undergoes radioactive decay.

3.1.66.1 *Discussion*—The emitted radiation types may include alpha particles, beta particles, gamma rays, and neutrons.

3.1.67 *radiation shielding window, n*—an optically transparent assembly that provides a means for viewing into a hot cell or other shielded facility and shields the operator from radiation.

3.1.68 *radiation streaming, n*—a term used to describe radiation escaping through an inadequately shielded material.

3.1.69 *rem (roentgen equivalent man)*, $[M^1TI]$, *n*—a measure of the damaging effects of ionizing radiation to man. See *dose equivalent*.

3.1.70 *roentgen (R)*, $[M^1\ TI]$, *n*—a unit of measure for radiation exposure. It is equivalent to 2.58×10^{-4} coulombs per kilogram of air.

3.1.71 *secondary gamma, n*—is radiation generated by reactions between primary gamma rays and the material through which it is traveling.

3.1.72 *shielding oil, n*—an optical grade mineral oil used to fill the voids between the glass slabs and couple the glass surfaces in an oil-filled lead glass shielding window assembly.

3.1.72.1 *Discussion*—The oil also provides minor gamma and neutron shielding.

3.1.73 *shielding wall plug, n*—a device constructed similar to that of a radiation shielding window, except that is has no visual capabilities for viewing into the hot cell.

3.1.73.1 *Discussion*—It is used only to plug the hole where a radiation shield window normally is installed. A shielding plug allows the Owner-Operator to move and interchange shielding windows to other locations. It is an effective tool in reducing operating and maintenance costs of a hot cell.

3.1.74 *shine, n—in the nuclear industry*, shine is direct, scattered, or reflected radiation.

3.1.75 *short finish, n*—the small microscopic pits normally found in the outer edges or corners on the surface of a polished plate or slab of glass. The pits do not affect the optical visibility through the glass.

3.1.76 *sievert (Sv)*, $[L^2\ T^2]$, *n*—the SI unit of measure for dose equivalent to humans.

3.1.76.1 *Discussion*—One sievert equals 100 rem.

3.1.77 *source, n—in the nuclear industry*, radioactive material that emits radiation.

3.1.77.1 *Discussion*—Testing or calibration typically uses a closed or sealed source which has well-known properties.

3.1.78 *stepped window, n*—a stepped shielding window is one that has one or more steps at its perimeter and provides an interruption in the potential radiation shine path from the hot side to the cold side of the window.

3.1.79 *streaming, n*—see *radiation streaming*.

3.1.80 *striae, n*—transparent lines appearing as though threads of glass have been incorporated into the glass sheet.

3.1.81 *stripping, n*—a streaking appearance on a polished glass surface with no measurable depth indicating a loss of polish without glass removal.

3.1.82 *total integrated dose (tid)*, $[L^2\ T^{-2}]$, *n*—is the total amount of radiation received by a component or location for the design life of the component.

3.1.82.1 *Discussion*—Total dose is computed by multiplying the dose rate(s) by the corresponding time(s) and summing the results over the time span. Another way to express this is as the area under the curve of a dose rate versus time diagram.

3.1.83 *trim frame, n*—a steel frame with a drilled hole pattern that functions to mechanically fasten a cover glass to a window housing.

3.1.84 *trim frame assembly, n*—consists of steel frames, gaskets and a glass plate (cover glass), assembled together to form a see-through cover glass.

3.1.84.1 *Discussion*—The assembly is mechanically fastened to the cold side or hot side of a window housing to provide a gas tight containment for the shielding window assembly.

3.1.85 *very high radiation area, n*—an area, accessible to individuals, in which radiation levels external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 h at 1 m from a radiation source or 1 m from any surface that the radiation penetrates. **(10 CFR20.1003)**

3.1.86 *viewing angle, n*—the term used to describe the widening view from the eyeball when looking through a shielding window into a hot cell.

3.1.87 *view port, n*—a small shielding window that is usually positioned in a cask, wall, or other shielded structure and is utilized for the express purpose of viewing a small area where a gauge, meter, valve, etc. might be located.

3.1.88 *WG, [ML^{-1} T^{-2}], n*—the abbreviation for *water gauge*.

3.1.88.1 *Discussion*—It is the pressure differential, equal to the pressure exerted by a column of water of the specified height.

3.1.89 *wall liner embedment, n*—a metal structure which is embedded in the hot cell wall.

3.1.89.1 *Discussion*—The radiation shielding window fits into the wall liner.

3.1.90 *window cavity, n*—the space inside the window housing that contains the glass slabs and lead packing.

3.1.91 *window housing, n*—the outer metal structure of the shielding window.

3.1.91.1 *Discussion*—It fits into the wall liner embedment.

3.1.92 *window interchangeability, n*—the ability to remove a shielding window of the same size from one embedment wall liner and move and install it into another embedment wall liner of the same size.

4. Significance and Use

4.1 *Radiation Shielding Window Components:*

4.1.1 Radiation shielding window components operability and long-term integrity are concerns that originate during the design and fabrication sequences. Such concerns can only be addressed, or are most efficiently addressed, during one or the other of these stages. The operability and integrity can be compromised during handling and installation sequences. For this reason, the subject equipment should be handled and installed under closely controlled and supervised conditions.

4.1.2 This standard is intended as a supplement to other standards and to federal and state regulations, codes, and criteria applicable to the design of radiation shielding window components.

5. Quality Assurance and Quality Requirements

5.1 *Quality Assurance (QA):*

5.1.1 The Manufacturer should administer a quality assurance program acceptable to the Owner-Operator. QA programs may be required to comply with 10 CFR50, Appendix B, 10 CFR830.120 Subpart A, ANSI/ASME NQA-1, or ANSI/ISO/ASQ 9001.

5.1.2 The Owner-Operator should require appropriate quality assurance of purchased radiation shielding window components to assure proper fit up, operation, and reliability of the components when they are installed in the hot cell.

6. Design Requirements

6.1 *General Requirements:*

6.1.1 *Application:*

6.1.1.1 The Owner-Operator shall specify whether the radiation shielding window shall be dry lead glass or oil filled lead glass, based on the application needs and preference. Considerations in making the determination should be based on viewing, seismic, neutron shielding, clarity, and maintenance requirements.

6.1.1.2 Materials of construction on the hot side shall be radiation resistant to the hot cell environment, easily decontaminated, and compatible with other materials with which they are in contact.

6.1.1.3 The radiation shielding components shall be designed to provide the required radiation shielding, hot side contamination containment, and viewing capability within the shielded hot cells.

6.1.2 *Configuration:*

6.1.2.1 The shielding window components shall be designed as cold side or hot side load with single or multiple steps. A cold side load window with a single step is the preferred method.

6.1.2.2 If the manufacturer elects to provide multiple stepped window components, he shall demonstrate to the Owner-Operator prior to fabrication release that the windows can be installed, extracted, and re-installed from the cold side with the barrier shield secured in place on the wall liner embedment.

6.1.3 *Radiation Environment and Shielding:*

6.1.3.1 *Attenuation:*

(1) Each radiation shielding window shall provide adequate radiation shielding for the radiation source in the respective cell.

(2) The Owner-Operator shall specify the source in terms of the specific isotopes, activity, its dose rate, its geometry, and its distance from the hot side of the window. Refer to Annex A1.

(3) The Owner-Operator shall specify the radiation level at the cold side of the window; for example, 2.5 μSv/h (0.25 mrem/h) at a distance of 150 mm (6 in.) from the surface of the cold side cover glass. It is recommended that the attenuation of the window match the attenuation of the hot cell wall.

6.1.3.2 *Build-Up Factor:*

(1) Unless otherwise specified by the Owner-Operator, the window shall be designed to accommodate the radiation build-up factor. Build-up Factor in shielding calculations takes account of scattered radiation. Most shielding calculations are based on highly collimated photon sources but normally, the source is only broadly collimated or uncollimated.

(2) Radiation scattered from elsewhere in the shield will reach a particular dose point under consideration. In general, build-up factor increases with shield thickness and is higher for low atomic number materials.

6.1.3.3 *Radiation Streaming:*

(1) Shielding shall be provided along any possible radiation path through the window penetration and the wall liner.

(2) Installation of shielding materials into the gaps between the window housing and the wall liner (with the exception of metal spacers) should not be permitted for new design and build windows to meet the dose rate requirement at the cold side of the window. This requirement is to eliminate the

potential for mixed hazardous waste such as contaminated lead packing that may be removed from the opening between the window and wall liner.

6.1.4 *Light Transmission:*

6.1.4.1 The minimum initial light transmission specified by the Owner-Operator for each type window shall be measured at a wavelength of 589 nanometres. Refer to A2.1 Sample Data Sheet.

6.1.5 *Dimensions:*

6.1.5.1 The minimum dimensions of the clear view and the maximum dimensions of the barrier shield assemblies shall be as specified by the Owner-Operator on the data sheet for each type of window.

6.1.5.2 The centerline viewing height of clear view (eye position above cold side floor), the offset viewing height (eye position above cold side floor), the offset viewing distance from clear view centerline, and the viewing distance (distance from eyeball to glass) shall be specified by the Owner-Operator on the data sheet for each type of window.

6.1.5.3 The hot side of the barrier shield cover glass should be designed to eliminate master-slave manipulator interference. Refer to Annex A3, Fig. A3.8.

6.1.6 *Wall Thickness, Density and Material:*

6.1.6.1 The Owner-Operator shall specify the wall thickness, density, and material. Refer to Annex A2.

6.1.7 *Viewing Angles:*

6.1.7.1 The Owner-Operator shall specify the minimum viewing angles as described in Annex A3, Figs. A3.3-A3.5, and on the Annex A2 Data Sheet.

6.1.7.2 Annex A3, Figs. A3.3-A3.5 shows typical calculated centerline and offset viewing angle geometry in horizontal and vertical sections, respectively.

6.1.8 *Physical Conditions:*

6.1.8.1 The Owner-Operator shall provide the necessary information regarding the design and operating requirements for the cold side and hot side of the window. Refer to Annex A1 – Annex A3.

6.1.9 *Seismic Requirements:*

6.1.9.1 The Owner-Operator shall provide seismic requirements for designing the shielding window components as determined by the ACI C-31 Seismic Requirements, the IBC Section 2314—Earthquake Regulations, or other seismic codes specific to the Owner-Operator's facility.

6.1.9.2 The shielding window components shall withstand seismic and other concurrent loads while maintaining containment and shielding during the event. Viewing functionality of the shielding windows during and after the event is not required, but shielding and containment must be maintained.

6.1.9.3 Seismic qualification of the shielding window components shall be by analysis unless otherwise specified by the Owner-Operator.

6.1.9.4 Friction, where not purposely designed (AISC friction type connection), shall not be relied upon as a resisting force during seismic events. Shielding window assemblies must be mechanically restrained to the wall.

6.1.10 *Design Life:*

6.1.10.1 The design life and radiological duty cycle of the windows shall be specified by the Owner-Operator.

6.2 *Wall Liner Embedments:*

6.2.1 *Design:*

6.2.1.1 The wall liners shall be of a single or multi-step construction to prevent radiation streaming. The wall liners shall be designed to provide the necessary shielding to compensate for the gap between the window housing and the wall liner. Refer to Annex A3, Figs. A3.1 and A3.2, for sketches of the shielding window configurations.

6.2.2 *Structure:*

6.2.2.1 The wall liners shall be constructed of carbon steel or stainless steel weldments or iron or stainless steel castings. It is recommended that the hot side of the wall liners, especially where there are corrosive environments, be constructed of stainless steel weldments or stainless steel castings. Porous castings that may trap contamination shall not be permitted.

6.2.2.2 Castings shall be inspected for surface defects and porosity after machining. Castings shall also be inspected for internal voids by ultrasonic or X-ray testing. These inspections verify surface and internal casting quality, which assures structural soundness, radiological containment, and adequate shielding.

6.2.2.3 Materials used in the construction of wall liners shall be suitable for the specific application as recommended by the designer or manufacturer, and as approved by the Owener-Operator. Refer to 7.2 Steel/Castings.

6.2.2.4 When the wall liners are to be flared out to the hot side to accommodate extreme viewing angles, the designer must ensure that attenuation provided by the wall is not compromised.

6.2.3 *Sealing System:*

6.2.3.1 The wall liners shall be designed to have a primary and secondary containment seal.

(1) The primary containment seal shall be at the hot side of the wall liner and shall be accomplished by sealing the barrier shield assembly to a machined surface of the hot side face of the wall liner.

(2) The secondary containment seal shall be at the cold side, or at the most cold side step of the wall liner, and shall be accomplished by sealing the window assembly to a machined surface at the cold side, or most cold side step, of the wall liner.

(3) The design shall be such that a gas-tight seal is formed in the cavity between the barrier shield and the window assembly when the shielding window assembly is inserted into the wall liner. Refer to Annex A3, Fig. A3.6 and Fig. A3.8, for sketches of trim frame configurations and stepped wall liner configuration.

6.2.4 *Gas Purge:*

6.2.4.1 An inert gas purge line and a gas vent line should be provided at the cold side wall liner face to supply and exhaust inert gas to and from the cavity between the barrier shield and window assembly.

6.2.4.2 Consideration shall be given not to exhaust contamination to the cold side, should the primary barrier shield seal malfunction. All seal welds shall be continuous so that the liner and flanges will provide an inert gas tight seal.

6.2.5 *Gaps—Liner to Housing:*

6.2.5.1 The interface between the wall liner and the shielding window assembly shall be designed to provide a gap at the top and sides to allow centering the shielding window in the wall liner cavity. The gap is to provide for window interchangeability.

6.2.5.2 A gap shall be provided between the window and the wall liner at the bottom. The inside bottom surface of the wall liner shall be designed to mate with the skids or rollers on the shielding window assembly.

6.2.6 *Concrete Anchors:*

6.2.6.1 Where required, the embedded wall liners shall have concrete anchors secured to the assembly exterior where the wall liner surfaces are in contact with the concrete wall.

6.2.7 *Liner Handling:*

6.2.7.1 Each wall liner shall have suitable lifting points for handling purposes.

6.2.8 *Temporary Bracing:*

6.2.8.1 The embedded wall liner will also be utilized as a form for placing concrete when the shielding wall is poured.

6.2.8.2 The Manufacturer shall provide and install internal horizontal and vertical temporary bracing as necessary for the embedded wall liners such that the required tolerances are maintained during shipment and installation.

6.2.8.3 Any bracing shall be placed such that the vent holes shall be accessible during the concrete pour.

6.2.8.4 The temporary bracing shall be removed at the time when the concrete forms are removed.

6.2.9 *Vent Holes:*

6.2.9.1 Vent holes shall be cut into the bottom surface of the wall liners as required to accommodate the removal of trapped air pockets during the concrete pour.

6.2.9.2 The vent holes in the wall liners shall be seal welded closed and liquid dye penetrant examined before window installation.

6.3 *Shielding Window Assemblies:*

6.3.1 *Design:*

6.3.1.1 The window housings shall be of a single or multi-step construction to prevent radiation streaming.

6.3.1.2 The window housings shall be designed to provide the necessary shielding to compensate for the gap between the window housing and the wall liner.

6.3.1.3 Shielding window assemblies of the same size shall be interchangeable with wall liners of the same size. Window designs (components and sub-assemblies) should be toleranced accordingly for interchangeability. Refer to Annex A3, Figs. A3.1 and A3.2, for sketches of the shielding window configurations.

6.3.2 *Structure:*

6.3.2.1 The shielding windows shall be dry lead glass or oil-filled lead glass.

6.3.2.2 The shielding window housings shall be constructed of carbon steel or stainless steel weldments, or iron or stainless steel castings. It is recommended that the hot side of the windows, where exposed to corrosive environments, be constructed of stainless steel weldments or stainless steel castings.

6.3.2.3 Materials used in the construction of shielding windows shall be suitable for the specific application as recommended by the designer or manufacturer, and as approved by the Owner-Operator. Refer to Section 7.2 Steel/Castings.

6.3.2.4 Shielding Windows designed with encased concrete or magnetite shall be provided with external vent holes near the cold side to relieve possible pressure buildup that may occur from the creation of hydrogen and oxygen gases caused by decomposition of the concrete or magnetite under long-term radiation exposure.

6.3.2.5 Porous castings that may trap contamination shall not be permitted. Castings shall be inspected for surface defects and porosity after machining. Castings shall also be inspected for internal voids by ultrasonic or X-ray testing. These inspections verify surface and internal casting quality, which assures structural soundness, radiological containment and adequate shielding.

6.3.3 *Sealing Systems:*

6.3.3.1 The window housing shall incorporate a gasket to provide a secondary containment seal at the cold side of the wall liner or at the most cold side step of the wall liner. This may be accomplished by machining a surface at the wall liner. The window manufacturer shall recommend a method to compress the seal at the wall liner. The purpose of the seal is to eliminate moisture between the hot side face of the window and barrier shield.

6.3.3.2 Carbon steel or stainless steel trim frame assemblies with cover glasses and sealing gaskets may be mounted at both the hot side and cold side faces of the shielding window assemblies, forming a gas tight chamber within the window cavities.

6.3.3.3 The Owner-Operator shall specify the requirement for a hot side trim frame assembly for a dry lead glass window.

6.3.3.4 The hot side and cold side surfaces of the window housings shall be designed to provide a sealing surface for the seal gaskets and a mounting surface for the trim frame assemblies as required.

6.3.3.5 The hot side seal gasket for the hot side cover glass where used shall be placed between the cold side face of the glass and the machined steel face at the hot side of the shielding window assembly.

6.3.3.6 The cold side seal gasket for the cold side cover glass shall be placed similarly.

6.3.3.7 The joints of the seal gaskets shall be vulcanized (not glued), or the gasket shall be cookie cut from a solid sheet of gasket material. Refer to Annex A3, Fig. A3.6 and Fig. A3.8, for sketches of trim frame configurations.

6.3.3.8 The compression gaskets shall be located between the trim frame clamping flange and the cover glass.

6.3.4 *Roller/Skids:*

6.3.4.1 A pair of skids shall be located on the underside of the shielding window assemblies. The purpose for the skids is to assist in the installation and removal of the windows and also to help properly align the window assemblies within the wall liners.

6.3.4.2 The skids shall be designed to match the internal bottom surfaces of the wall liners and to insure a perpendicular fit-up. Machining of matching surfaces is recommended.

6.3.4.3 An alternative method to using skids is to use rollers mounted in the external underside of the shielding window assemblies.

6.3.5 *Window Handling:*

6.3.5.1 The windows shall be provided with suitable lifting points.

6.3.5.2 A suitable attachment method for extracting and installing the windows shall be provided.

6.3.6 *Shielding Glass:*

6.3.6.1 Polished glass slabs shall be installed into the window housings and secured to the interior sides of the window housings with lead packing or other suitable shielding material.

6.3.6.2 The window assemblies shall provide the desired shielding while maintaining optical clarity.

6.3.6.3 The glass slabs shall be secured within the window housings in a manner as to prevent loss of shielding during a seismic event. Refer to paragraph 6.3.11.2.

6.3.7 *Cover Glasses:*

6.3.7.1 The hot side cover glass, where installed, shall provide as a minimum 25 % greater allowable surface pressure than the cold side cover glass. The purpose for this requirement is to assure the cold side cover glass ruptures first in the event of over-pressurization of the shielding window assembly.

6.3.7.2 During purging and oil changing, a polycarbonate panel should be installed over the external surface of the cold side cover glass and mounted to the trim frame. This panel shall serve as a safety shield in case the cold side cover glass ruptures.

6.3.8 *Purge Systems:*

6.3.8.1 *Design:*

(1) Where excessive temperature cycling may be present, it is important to keep ambient air and moisture from entering the internal window cavity to prevent filming on the internal glass surfaces.

(2) Provisions shall be made in the shielding window assemblies for the free flow of inert gas, or shielding oil beneath each internal glass slab, and for the venting of inert gas, or flow of shielding oil over the top of each internal glass slab during the purging or oil filling and oil draining processes.

(3) Passages for inert gas and oil flow shall be designed with offsets to prevent radiation streaming through the shielding window.

(4) The shielding window assemblies shall be designed such that they may be filled, drained, gas purged, and vented from the cold side, without removal of the shielding window assemblies from the wall liners.

(5) There shall be no residual oil trapped at the bottom of the shielding window assemblies when the oil is drained and there shall be no air pockets trapped at the top of the shielding window assemblies when the shielding windows are filled with oil.

(6) The oil fill and drain system should be designed such that the entire shielding window assembly can be filled or drained without interruption of flow in approximately one hour. This recommendation is to eliminate potential stain lines on the glass surfaces due to interruption of oil flow.

6.3.9 *Components:*

6.3.9.1 All fittings and valves shall be stainless steel. No fluoropolymer resin packing shall be allowed in the valves or used as a thread sealant on the threaded fittings.

6.3.9.2 A desiccant air dryer assembly shall be mounted above each shielding window and connected to the window ventilation system (both inside the window and between the window and wall liner cavity) and also to the inert gas purge system. On an oil window, the desiccant air dryer shall be located above the oil expansion tank.

6.3.9.3 The inert gas purge system shall have a pressure reduction valve and a pressure relief valve or bubbler system to reduce the inert gas pressure on the windows to a maximum of 1.7 kPa (0.25 psi).

6.3.9.4 There shall be a valve in line above the desiccant air dryer assembly to shut off the supply of the inert gas when changing out the air dryer crystal cartridge.

6.3.9.5 The air dryer shall be easily accessible for change out of the air dryer cartridge.

6.3.9.6 There shall also be a valve mounted on the lower cold side face of the shielding window assembly for draining oil from the window or for purging and venting the window.

6.3.9.7 Where an inert gas system is unavailable or impractical, the top of the air dryer shall be sealed with an expandable bellows of neoprene or other suitable material to seal the window cavity from the ambient air and still allow for expansion of the inert gas or shielding oil. Bellows manufactured of latex material are not recommended.

6.3.10 *Oil Expansion Tank:*

6.3.10.1 An oil expansion tank shall be provided for each oil-filled shielding window assembly. The oil expansion tank shall be mounted at the Manufacturer's recommended height above the top of the cold side cover glass, and shall be free from all interference from other equipment. A recommended practice is to mount the oil expansion tank no more than 2 ft. above the window assembly to prevent over-pressurization of the window.

6.3.10.2 The expansion tank shall be constructed of stainless steel (preferred) or glass and shall provide adequate expansion for the shielding oil in the window assembly.

6.3.10.3 The expansion tank shall be designed and mounted in a manner so that no residual oil remains in the tank when the tank is drained.

6.3.10.4 It shall have a bottom connection for feeding oil to the window, a top connection for connecting to the inert gas purge line, and a replaceable sight gauge for visually checking the oil level in the expansion tank.

6.3.10.5 The expansion tank shall be leak tested to the same pressure requirements as the window housing.

6.3.11 *Seismic Restraints:*

6.3.11.1 Seismic restraints shall be bolted to the cold side face of each wall liner to secure each shielding window assembly in position.

6.3.11.2 Stainless steel seismic restraints shall be positioned inside of the window assembly to secure the glass components from movement. Carbon steel should not be used.

6.3.12 *Installation/Removal:*

6.3.12.1 The shielding window assemblies are typically moved with the use of a lift truck, bridge crane, or boom crane.

6.3.12.2 The window assemblies shall be installed with the use of an installation/extraction table or other suitable device.

6.3.12.3 The insulated multi-strand copper grounding strap must be fastened to the cold side face of the window assembly and connected to the building ground system during installation. A continuity check shall be made between the shielding window and the building ground upon completion of the installation to ensure proper grounding.

6.4 *Shielding Wall Plugs:*

6.4.1 *Design:*

6.4.1.1 The shielding plugs shall have the same external configuration as the shielding windows and shall be of a single or multi-step construction to prevent radiation streaming.

6.4.1.2 The shielding plugs shall be designed to provide the necessary shielding to compensate for the gap between the shielding plug and the wall liner.

6.4.1.3 Shielding plugs of the same size shall be interchangeable as though they were shielding windows fitting into wall liners of the same size. Shielding plug designs (components and sub-assemblies) should be toleranced accordingly for interchangeability. Refer to Annex A3, Figs. A3.1 and A3.2, for sketches of the shielding window configurations.

6.4.2 *Structure:*

6.4.2.1 The shielding plugs shall be constructed of carbon steel or stainless steel weldments, or iron or stainless steel castings. It is recommended that the hot side of the plugs, where exposed to corrosive environments, be constructed of stainless steel weldments or stainless steel castings.

6.4.2.2 Porous castings that may trap contamination shall not be permitted. Castings shall be inspected for surface defects and porosity after machining. Castings shall also be inspected for internal voids by ultrasonic or X-ray testing. These inspections verify surface and internal casting quality, which assures structural soundness, radiological containment, and adequate shielding.

6.4.2.3 Materials used in the construction of shielding plugs shall be suitable for the specific application as recommended by the designer or manufacturer, and as approved by the Owner-Operator. Refer to 7.2, Steel/Castings.

6.4.2.4 Shielded Wall Plugs designed with encased concrete or magnetite shall be provided with external vent holes near the cold side to relieve possible pressure buildup that may occur from the creation of hydrogen and oxygen gases caused by decomposition of the concrete or magnetite under long-term radiation exposure.

6.4.3 *Sealing System:*

6.4.3.1 The shielding plug shall incorporate a gasket to provide a secondary containment seal at the cold side of the wall liner or at the most cold side step of the wall liner. This may be accomplished by machining a surface at the wall liner. The manufacturer shall recommend a method to compress the seal at the wall liner. The purpose of the seal is to eliminate moisture between the hot side face of the plug and barrier shield.

6.4.4 *Rollers/Skids:*

6.4.4.1 A pair of skids shall be located on the underside of the shielding plugs. The purpose of the skids is to assist in the installation and removal of the shielding plugs and also to help properly align the shield plugs within the wall liners.

6.4.4.2 The skids shall be designed to match the internal bottom surfaces of the wall liners and to ensure a perpendicular fit-up. Machining of matching surfaces is recommended.

6.4.4.3 An alternative method to using skids is to use rollers mounted in the external underside of the shielding plugs.

6.4.5 *Shielding Wall Plug Handling:*

6.4.5.1 The shielding plugs shall be provided with suitable lifting points. A suitable attachment method for extracting and installing the shielding plug shall be provided.

6.4.6 *Seismic Restraints:*

6.4.6.1 Seismic restraints shall be bolted to the cold side face of each wall liner to secure each shielding plug in position.

6.4.7 *Installation/Removal:*

6.4.7.1 The shielding plugs are typically moved with the use of a lift truck, bridge crane, or boom crane.

6.4.7.2 The shielding plugs shall be installed with the use of an installation/extraction table or other suitable device.

6.4.7.3 The insulated multi-strand copper grounding strap must be fastened to the cold side face of the shielding plug and connected to the building ground system during installation. A continuity check shall be made between the shielding plug and the building ground upon completion of the installation to ensure proper grounding.

6.5 *Barrier Shield Assemblies:*

6.5.1 *Design:*

6.5.1.1 The barrier shield frame shall be of a size sufficient to carry the weights of itself, the barrier shield glass, and the other components that make up the barrier shield, with minimal deformation. Refer to Annex A3, Figs. A3.7 and A3.8, for sketches of the barrier shield configurations.

6.5.2 *Structure:*

6.5.2.1 Consideration shall be given to the hot cell environment, ability to decontaminate, and compatibility with other materials in which they are in contact, when selecting materials of construction.

6.5.2.2 The barrier shield frames shall be constructed of fabricated carbon steel or stainless steel weldments, or iron or stainless steel castings. It is recommended the barrier shield frames, where exposed to corrosive environments be constructed of stainless steel weldments or stainless steel castings.

6.5.2.3 Porous castings that may trap contamination shall not be permitted. Castings shall be inspected for surface defects and porosity after machining. Castings shall also be inspected for internal voids by ultrasonic or X-ray testing. These inspections verify surface and internal casting quality, which assures structural soundness, radiological containment, and adequate shielding.

6.5.2.4 Materials used in the construction of barrier shield frames shall be suitable for the specific application as recommended by the designer or manufacturer, and as approved by the Owner-Operator. Refer to 7.2, Steel/Castings.

6.5.3 *Barrier Shield Glass and Assemblies:*

6.5.3.1 The barrier shield glass shall provide as a minimum 25 % greater allowable surface pressure than the cold side cover glass.

6.5.3.2 The barrier shield assembly shall provide mechanical protection for the shielding window assembly and shall provide a gas tight buffer seal so that the shielding window assembly can be removed from the wall liner without breaching the containment boundary.

6.5.4 *Hot Side Window Guard:*

6.5.4.1 Where appropriate for safety protection from glass breakage or dielectric discharging due to manipulator arms impacting the hot side glass surface; consideration should be given to the installation of a removable metal grid, polycarbonate sheet, or other suitable guard at the very hot side of the barrier shield.

6.5.5 *Sealing System:*

6.5.5.1 The barrier shield assembly shall have a buffer seal gasket, which seals the barrier shield assembly to the wall liner flange.

6.5.6 *Installation/Removal:*

6.5.6.1 For remote operations, the barrier shield shall be capable of being removed and replaced remotely from the hot side of the window assembly.

6.6 *View Ports:*

6.6.1 *Design:*

6.6.1.1 The view port housings shall be of a single or multi-step construction to prevent radiation streaming.

6.6.1.2 The view port housings shall be designed to provide the necessary shielding to compensate for the gap between the view port housing and the wall liner.

6.6.1.3 View port assemblies of the same size shall be interchangeable with wall liners of the same size. View port designs (components and sub-assemblies) should be toleranced accordingly for interchangeability.

6.6.2 *Structure:*

6.6.2.1 The view ports shall be dry lead glass.

6.6.2.2 The view port housings shall be constructed of carbon steel or stainless steel weldments or iron or stainless steel castings. It is recommended that the hot side of the view ports, where exposed to corrosive environments, be constructed of stainless steel weldments or stainless steel castings.

6.6.2.3 Porous castings that may trap contamination shall not be permitted. Castings shall be inspected for surface defects and porosity after machining. Castings shall also be inspected for internal voids by ultrasonic or X-ray testing. These inspections verify surface and internal casting quality, which assures structural soundness, radiological containment, and adequate shielding.

6.6.2.4 Materials used in the construction of view ports shall be suitable for the specific application as recommended by the designer or manufacturer, and as approved by the Owner-Operator. Refer to 7.2 Steel/Castings.

6.6.2.5 View Ports designed with encased concrete or magnetite shall be provided with external vent holes near the cold side to relieve possible pressure buildup that may occur from the creation of hydrogen and oxygen gases caused by decomposition of the concrete or magnetite under long-term radiation exposure.

6.6.3 *Sealing System:*

6.6.3.1 The view port shall incorporate a gasket to provide a secondary containment seal at the cold side of the wall liner or at the most cold side step of the wall liner. This may be accomplished by machining a surface at the wall liner. The manufacturer shall recommend a method to compress the seal at the wall liner. The purpose of the seal is to eliminate moisture between the hot side face of the view port and barrier shield.

6.6.3.2 Carbon steel or stainless steel trim frame assemblies or corner clips may be used to secure cover glasses and sealing gaskets at both the hot side and cold side faces of the view port assemblies.

6.6.4 *View Port Handling:*

6.6.4.1 The view ports shall be provided with suitable lifting points.

6.6.4.2 A suitable attachment method for extracting and installing the view ports shall be provided.

6.6.5 *Cover Glasses:*

6.6.5.1 Cover glasses may be bonded or laminated to the shielding glass in a view port assembly.

6.6.6 *Seismic Restraints:*

6.6.6.1 Seismic restraints shall be bolted to the cold side face of each wall liner to secure each view port assembly in position.

6.6.6.2 Stainless steel seismic restraints shall be positioned to secure the glass components within the view port assembly. Carbon steel shall not be used.

6.6.7 *Installation/Removal:*

6.6.7.1 The view port assemblies are typically moved with the use of a lift truck, bridge crane, or boom crane.

6.6.7.2 The view port assemblies shall be installed with the use of an installation/extraction table or other suitable device.

6.6.7.3 The insulated multi-strand copper grounding strap must be fastened to the cold side face of the view port assembly and connected to the building ground system during installation. A continuity check shall be made between the view port and the building ground upon completion of the installation to ensure proper grounding.

6.7 *Installation/Extraction Table/Device:*

6.7.1 *Design:*

6.7.1.1 The installation/extraction table/device or other suitable equipment shall be designed to perform installation and removal of the shielding windows, shielding plugs, and view ports into or out of the wall liner openings from the cold side of the hot cell.

6.7.2 *Structure:*

6.7.2.1 The table/device shall be constructed of fabricated carbon steel or stainless steel for ease of decontamination. Cast iron or cast stainless steel shall not be used in any weight bearing member.

6.7.2.2 The table/device shall be designed to safely raise a load of 1.5 times the actual load being raised to the desired height for installation or removal.

6.7.2.3 Materials used in the construction of table/device shall be suitable for the specific application as recommended by the designer or manufacturer, and as approved by the Owner-Operator. Refer to 7.2, Steel/Castings.

6.7.3 *Overturning:*

6.7.3.1 The design shall include features that permit attaching the table/devise to the wall liner to eliminate movement and