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Standard Guide for Dry Lead Glass and Oil-Filled Lead Glass Radiation Shielding Window Components for Remotely Operated Facilities¹

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 This~~ 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~~ 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.~~

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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 ~~Hazards~~ 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

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maintenance of radiation shielding window components are referenced throughout this standard and include the following:

2.2 ~~ASTM Standards:~~ *ASTM Standards:*²

[A27/A27M Specification for Steel Castings, Carbon, for General Application](#)

[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~~

[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

~~C-31~~ [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

~~Y14~~ [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](#)

~~D1.6~~ [ANSI/AWS D1.6/D1.6M Structural Welding Code—Stainless Steel](#)

~~Q900~~ [ANSI/ISO/ASQ 9001 Quality Management Standard Requirements](#)

2.5.2.6 *American Society for Nondestructive Testing (ASNT) Standards:*⁶

[ASNT-SNT-TC-1A Recommended Practice for Qualification and Certification of Nondestructive Testing](#)

~~2-6~~

2.7 *Steel Structures Painting Council (SSPC):*⁷

[SSPC-SP1 Solvent Cleaning](#)

[SSPC-SP6 Commercial Blast Cleaning](#)

[SSPC-P1 Paint Application Specification](#)

2.7.2.8 *Federal Standards (FS):*⁸

[QQ-C-40 Caulking, Lead Wool, and Lead Pig](#)

2.8 *Federal Regulations (FR):*⁷

2.9 *Federal Regulations (FR):*⁸

[10 CFR 20.1003 Definitions](#)

[10 CFR 50, Appendix B Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants](#)

~~10 CFR 830.120 Subpart A, A~~ [Nuclear Safety Management, Quality Assurance Requirements](#)

2.9.2.10 *International Building Code (IBC):*⁸

[IBC Section 2314 Earthquake Regulations](#)

~~2-10~~

2.11 *Other Standards:*

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 American Concrete Institute (ACI) Standards, 38800 Country Club Drive, Farmington Hills, MI 48331.

³ Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.concrete.org>.

⁴ American National Standards Institute (ANSI) Standards, 1819 L St. NW Washington D.C., 20036.

⁴ Available from American Institute of Steel Construction (AISC), One E. Wacker Dr., Suite 700, Chicago, IL 60601-2001, <http://www.aisc.org>.

⁵ American Society of Nondestructive Testing (ASNT) Standards, PO Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518.

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

⁶ Steel Structures Painting Council (SSPC), 40 24th Street 6th Floor, Pittsburgh, PA 15222.

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 U.S. Government Printing Office, Superintendent of Documents, Mail Stop SSOP, Washington DC 20402-9328.

⁷ Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, <http://www.sspc.org>.

⁸ HMSO, St. Clements House, 2-16 Colegate, Norwich, NR3 1BQ. UK.

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>.

AESS (R) 44/70000/6 Atomic Energy Standard Specification for Shielding Glass
 NCRP Report No. 82 ~~SI Units in Radiation Protection and Measurements~~⁹
 NCRP Report No. 82 SI Units in Radiation Protection and Measurements¹⁰
 ICRU Report 10b Physical Aspects of Irradiation¹¹

3. Terminology

3.1 Definitions:

3.1.1 *absorbed dose*—the quotient of the mean energy (E) imparted by ionizing radiation to matter of mass (M). The SI unit for absorbed dose is the gray, defined as 1 joule/kg and is equivalent to 100 rads. absorbed dose, D, [L²T⁻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*—the measure of the rate of spontaneous nuclear transformations of a radioactive material. The SI unit for activity is the becquerel, defined as 1 transformation per second. The original unit for activity was the curie (Ci), defined as 3.7×10^{10} ^{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*—see *radiation*. *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.

3.1.6 *as-built drawings* ~~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 contaminants).

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)*—see *activity*. *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*—see *radiation*. *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* ~~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* ~~buffer seal, n~~—a specially configured seal gasket used on a barrier shield.

3.1.15 *build-up factor*—term used for radiation passing through a medium, which is the ratio of the total value of a specific radiation quantity (such as absorbed dose) at any point in that medium to the contribution to that quantity from the incident

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

⁹ HMSO, St. Clements House, 2-16 Colegate, Norwich, NR3 1BQ, UK.

¹⁰ Available from International Commission on Radiation Units Protection and Measurements, Inc., 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814-3095.

¹¹ American Institute of Steel Construction, 101 Park Ave., New York 17, N.Y.

¹¹ Available from International Commission on Radiation Units and Measurements, Inc., 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814-3095.

uncollided radiation reaching that point. **E170 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 *central viewing area*—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 percent of the maximum usable viewing window dimensions. *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 *cerium-stabilized glass*—often called non-browning glass is a glass type that contains a small percentage of cerium oxide to help stabilize the glass from discoloration due to radiation exposure. *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 *certified material test report (CMTR)*—a document that certifies the results of tests and analyses performed on the item provided. *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 *checks*—very small fractures, or breakouts normally around the edge of a glass plate, or glass slab. *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 *chip*—a fragment broken from an edge or surface. *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 *clear view*—the physical size (length \times width), of the smallest glass slab of all the glass components in a shielding window assembly. (The actual clear view may be reduced by the method of retention of the glass in the window.) *checks, n* —very small fractures, or breakouts, normally around the edge of a glass plate or glass slab.

3.1.22 *cold side*—the surface on a radiation shielding window that is farthest from the radioactive source, and usually is not subject to contamination. *chip, n* —a fragment broken from an edge or surface.

3.1.23 *cold side load*—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. *clear view, [L^2], n* —the physical size (length \times 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 *cover glass (hot or cold side)*—a glass plate positioned on the hot or cold side of the window. 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. *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 *curie*—see activity. *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 *density inch*—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) \times inch. *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 *desiccant air dryer*—a device filled with crystals, and is used to remove moisture from a contained environment. *curie (Ci), [T^1], n* —the original unit of measure for activity, defined as 3.7×10^{10} transformations per second.

3.1.28 *dielectric discharge*—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. *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 \times (in.).

3.1.29 *dose equivalent*—represents a quantity used for radiation protection purposes that expresses on a common scale, the dose from all types of radiation. Dose equivalent is the product of absorbed dose (D), a quality factor that normalizes the effects between different radiation types (Q) and other modifying factors (N). The specialized unit for dose equivalent is the rem. The quality factors are specified by the International Commission on Radiological Units and Measurements for different types of radiation and organ exposures. 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 (μ Sv), 1×10^{-6} sieverts, or in terms of millirem (mrem), 1×10^{-3} . 10 μ Sv is equal to 1 mrem.

—**NCRP-82, ICRU-10b desiccant air dryer, n** —a device filled with crystals and is used to remove moisture from a contained environment.

3.1.30 *dose rate*—a quantity of absorbed dose received in a given unit of time. *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 *dry lead glass window*—a radiation shielding window that is filled with slabs of lead glass with polished glass surfaces. 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. *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 (μ Sv) or millirem (mrem).

3.1.32 *exposure*—the quotient of the total charge of ions of one sign produced in air when all electrons are liberated by photons in a volume element of air mass sufficient to completely stop the electrons (charged particle equilibrium). Radiation exposure is a measure of the amount of ionization produced by x-ray or gamma rays as they travel through air. The special unit of exposure is the roentgen (R). It is equivalent to 2.58×10^{-4} coulombs per kilograms of air. *NCRP-82 dose rate, $[L^2 T^{-3}]$, n* —a quantity of absorbed dose received in a given unit of time.

3.1.33 *extraction/installation table/device*—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. *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 *extreme view angle*—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. *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 *gamma*—see *radiation*. *electro-mechanical manipulator (E/M), n* —a remotely operated handling and lifting device used to manipulate equipment in a hot cell that is too 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 *gas purge line*—a stainless steel tube supplying a pressurized gas to the window assembly. *exposure, $[M^1 T^1]$, 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 *gas-tight seal*—a seal that meets the requirements of a leak rate test. *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 *gas vent line*—a stainless steel tube connected to the window assembly for the purpose of venting gas. *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 *glass plate*—typically used as cover glasses or barrier shields. The maximum thickness is typically 40 mm (1.5 in.) thick. *gas purge line, n* —a stainless steel tube supplying a pressurized gas to the window assembly.

3.1.40 *glass slabs*—typically used for internal shielding in windows and view ports. The typical thickness ranges from a minimum of 40 mm (1.5 in.) up to a maximum of 400 mm (16 in.) thick. *gas-tight seal, n* —a seal that meets the requirements of a leak rate test.

3.1.41 *glass surface defects*—refer to those defects that are on the glass surface, and can be removed by reprocessing or repolishing the glass surface. These defects are scratches, short finish, and stripping. *gas vent line, n* —a stainless steel tube connected to the window assembly for the purpose of venting gas.

3.1.42 *gray (Gy)*—see *absorbed dose*. *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 *high density concrete*—a concrete having a weight of greater than 2400 kg per cubic meter (150 lb per cubic foot). *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 *hot cell*—an isolated shielded room that provides a controlled environment for containing radioactive material and equipment. The radiation levels within a hot cell are typically 1 Gy/h (100 rads per hour) or higher. *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 *hot side*—the surface on a radiation shielding window that when installed, will be the closest to the radioactive sources.

gray (Gy), [L² T⁻²], *n*—a gray is the SI unit of absorbed dose (1 J/kg).

3.1.46 *inclusions*—“small bubbles,” “small black stones,” and “seeds” that are visible in optical quality glass. *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 *inert gas*—a type of commercial grade moisture free gas, usually argon or nitrogen that is purged into the internal window assembly to displace ambient air. *high level caves*, *n*—a small-scale hot cell facility.

3.1.48 *lead packing*—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. 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. *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 *light transmission*—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. *hot side*, *n*—the surface on a radiation shielding window that, when installed, will be the closest to the radioactive sources.

3.1.50 *master-slave manipulator*—a device used to remotely handle radioactively contaminated items, or nuclear material in a hot cell. The uncontaminated or “clean” portion of the manipulator is called the “master” and the contaminated portion of the manipulator or follower is called the “slave.” Mechanical master-slave manipulators are mounted through the wall of the hot cell or pass through the ceiling. Powered manipulators can be electric or hydraulic. The extensions and fingers of the slave components inside the hot cell duplicate the manipulations of the arms and fingers of the operator at the cold side face of the cell. *inclusions*, *n*—“small bubbles,” “small black stones,” and “seeds” that are visible in optical quality glass.

3.1.51 *millirem (mrem)*—see *dose equivalent*. *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 *NCR*—the abbreviation for a Manufacturer’s Non-Conformance Report (NCR). 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. *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 *neutron*—see *radiation*. *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 *non-browning glass*—a glass type that resists discoloration due to high radiation exposure. *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 *normal concrete*—a concrete mixture that has a weight of between 2250 and 2400 kg per cubic meter (140 to 150 lb per cubic foot). *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 *normal view angle*—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. *mini-cell*, *n*—a very small, hot cell.

3.1.57 *oil expansion tank*—a stainless steel (preferred), 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. The oil supply in the window is connected to the expansion tank. *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 *oil-filled lead glass window*—a lead glass radiation shielding window filled with an optical grade shielding oil. *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 *polished glass surface*—a glass surface that has been polished and has minimal visual defects such as scratches and short finish. *non-browning glass*, *n*—a glass type that resists discoloration due to high radiation exposure.

3.1.60 *roentgen (R)*—see *exposure*. *normal concrete*, *n*—a concrete mixture that has a weight of between 2250 and 2400 kg per m³ (140 to 150 lb/ft³).

3.1.61 *radiation absorbed dose (rad)*—see *absorbed dose*. *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 *radiation*—*for purposes of this standard*, is defined as the emission that occurs when a nucleus undergoes radioactive decay. The emitted radiations may include alpha and beta particles, gamma rays, and neutrons. — **E170 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 *alpha*—alpha radiation is an alpha particle composed of two protons and two neutrons with a positive charge of plus two. (It is the same as a helium atom with no electrons.)

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

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

3.1.62.4 *neutron*—neutron radiation results from instability in the atomic nucleus that may be the result of either radioactive instability of the nucleus, interaction of the nucleus with another particle or energy source. Neutrons have an atomic mass slightly heavier than a proton, but have no electrical charge. *Discussion*—Stainless steel is the preferred type. The oil supply in the window is connected to the expansion tank.

3.1.63 *radiation shielding window*—*for purposes of this standard*, is an optically transparent instrument that provides a means for viewing into a hot cell, and shields the operator while performing work. A shielding window is generally constructed of an outer metal frame, called a housing and is filled with optically polished lead glass slabs that are secured within the housing with lead packing. Most shielding windows have cover glasses and trim frames on both viewing ends to seal the window cavity. The shielding windows can be either dry or oil-filled. *oil-filled lead glass window*, *n*—a lead glass radiation shielding window filled with an optical grade shielding oil.

3.1.64 *radiation streaming*—a term used to describe unshielded beams of radiation. *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 *roentgen equivalent man (rem)*—see *dose equivalent* $[L^2 T^{-2}]$, *n*—a unit of measure of radiation absorbed dose. See *absorbed dose*.

3.1.66 *shielding oil*—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. The oil also provides minor gamma and neutron shielding. *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 *shielding plug*—a device constructed similar to that of a radiation shielding window, except that it has no visual capabilities for viewing into the hot cell. 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. *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 *shine*—see *radiation streaming*. *radiation streaming*, *n*—a term used to describe radiation escaping through an inadequately shielded material.

3.1.69 *short finish*—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.

3.1.70 *sievert*—see *dose equivalent* $[M^1 TI]$, *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 *stepped window*—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. *secondary gamma*, *n*—is radiation generated by reactions between primary gamma rays and the material through which it is traveling.

3.1.72 *source*—the radioactive material inside the hot cell. The source emits radiation energy, which requires shielding to protect personnel. *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 *streaming*—see *radiation streaming*. *shielding wall plug*, *n*—a device constructed similar to that of a radiation shielding window, except that it 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 *striae*—transparent lines appearing as though threads of glass have been incorporated into the glass sheet. *shine*, *n*—*in the nuclear industry*, shine is direct, scattered, or reflected radiation.

3.1.75 *stripping*—a streaking appearance on a polished glass surface with no measurable depth indicating a loss of polish without glass removal. *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 *trim frame*—a steel frame with a drilled hole pattern. Its function is to mechanically fasten a cover glass to a window housing. sievert (Sv), [L² 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 *trim frame assembly*—consists of steel frames, gaskets and a glass plate (cover glass), assembled together to form a see through cover glass. 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. 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 *viewing angle*—the term used to describe the widening view from the eyeball, when looking through a shielding window into a hot cell. 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 *view port*—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. streaming, *n*—see *radiation streaming*.

3.1.80 *WG*—the abbreviation for “water gauge.” It is the pressure differential, equal to the pressure exerted by a column of water of the specified height. striae, *n*—transparent lines appearing as though threads of glass have been incorporated into the glass sheet.

3.1.81 *wall liner embedment*—a metal structure, which is embedded in the hot cell wall. The radiation shielding window fits into the wall liner. 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 *window cavity*—the space inside the window housing that contains the glass slabs and lead packing. total integrated dose (tid), [L² 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 *window housing*—the outer metal structure of the shielding window. It fits into the wall liner embedment. 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 *window interchangeability*—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. 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 operability and long-term integrity are concerns that originate during the design, 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 his 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, 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 load, or hot side load, 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 $\mu\text{Sv/h}$ (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, 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, housing and the wall liner (with the exception of metal spacers) should not be permitted for new design and build windows, 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 nanometers. 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 ~~American Concrete Institute ACI C-31 Seismic Requirements, the International Building Code Seismic Requirements, the IBC Section 2314—Earthquake Regulations~~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,~~ 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~~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 Owner-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,~~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,~~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 ~~and/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 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.~~

~~6.3.2.1 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 be designed with a machined surface 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.~~

~~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, 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, 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