INTERNATIONAL

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Standard Guide for Design Criteria for Plutonium Gloveboxes[1]

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1. Scope

1.1 This guide defines criteria for the design of glovebox systems to be used for the handling of plutonium in any chemical or physical form or isotopic composition or when mixed with other elements or compounds. Not included in the criteria are systems auxiliary to the glovebox systems such as utilities, ventilation, alarm, and waste disposal. Also not addressed are hot cells or open-face hoods.

1.2 The scope of this guide excludes specific license requirements relating to provisions for criticality prevention, hazards control, safeguards, packaging, and material handling. Observance of this guide does not relieve the user of the obligation to conform to all federal, state, and local regulations for design and construction of glovebox systems.

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

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

A269/A269M Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

A312/A312M Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

A376/A376M Specification for Seamless Austenitic Steel Pipe for High-Temperature Service

A480/A480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

A999/A999M Specification for General Requirements for Alloy and Stainless Steel Pipe

A1016/A1016M Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes

F837 Specification for Stainless Steel Socket Head Cap Screws

2.2 *Other Standards, Codes, and Guidelines*

ANSI N13.1 Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities[3]

ANSI/ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications[3]

ANSI/ASME AG-1 Code on Nuclear Air and Gas Treatment[3]

NFPA-70 National Electrical Code[4]

NFPA 72 National Fire Alarm Code[4]

NFPA 801 Standard for Fire Protection for Facilities Handling Radioactive Materials

DOE-HDBK-1081-94 DOE Handbook on Primer of Spontaneous Heating and Pyrophoricity[5]

[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.

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

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

[5] Available to the public from the U.S. Department of Commerce, Technology Administration, National Technical Information Service, Springfield, VA 22161.

10 CFR 20 Standards for Protection Against Radiation[6]

10 CFR 50 Domestic Licensing of Production and Utilization Facilities[6]

40 CFR 260–279 Solid Waste Regulations—Resource Conservation and Recovery Act (RCRA)[6]

10 CFR 830 Subpart A Quality Assurance Requirements[6]

AGS-G001-2007 Guideline for Gloveboxes, Third Edition[7]

AGS-G004-2014 Standard of Practice for Leak Test Methodologies for Gloveboxes and Enclosures[7]

AGS-G005-2014 Standard of Practice for the Specification of Gloves for Gloveboxes[7]

AGS-G006-2005 Standard of Practice for the Design and Fabrication of Nuclear-Application Gloveboxes[7]

AGS-G010-2011 Standard of Practice for the Glovebox Fire Protection[7]

AGS-G013-2011 Guideline for Glovebox Ergonomics[7]

3. Significance and Use

3.1 The purpose of this guide is to establish criteria for the design of gloveboxes as primary confinement systems to ensure the safety of the workers and the protection of the environment when storing, handling, processing, and disposing of both combustible and non-combustible forms of plutonium. The use of this guide will provide the user with guidance to design a successfully performing glovebox system.

4. Quality Assurance

4.1 A quality assurance program should be established for the design, fabrication, construction, acceptance testing, and operation, including modifications, repairs, replacement and maintenance of structures, systems, and components important to safety. Quality assurance requirements should be specified in the purchase order or contract (see 10 CFR 50 Appendix B, 10 CFR 830 Subpart A, and ANSI/ASME NQA-1).

5. Design Considerations

5.1 Design considerations should include engineered safety features and redundant plant services to achieve confinement reliability. Reliability should be considered in the light of the risk associated with postulated accidents (for example, accidents resulting from pyrophoric behavior of metallic plutonium), the probability of occurrence of the accidents, and the severity of their consequences, as well as in the light of normal processing requirements. The design for the glovebox system should consider all of the following subjects:

5.1.1 Fire,

5.1.2 Explosions,

5.1.3 Seismic events,

5.1.4 Installation and removal from service,

5.1.5 Automated equipment,

5.1.6 Glovebox process operations,

5.1.7 Criticality,

5.1.8 Confinement system leaks,

5.1.9 Power failure,

5.1.10 Service water failure,

5.1.11 Other services failure,

5.1.12 Glovebox pressurization,

5.1.13 Glovebox evacuation,

5.1.14 Health physics,

5.1.15 Need for glovebox isolation or compartmentalization or both,

5.1.16 Maintenance,

5.1.17 Ergonomics,

5.1.18 Decontamination methods, and

5.1.19 Chemical compatibility and corrosion resistance.

6. Glovebox System Design Features

6.1 The glovebox system is defined as a series of physical barriers provided with glove ports and gloves, through which process and maintenance operations may be performed, together with an operating ventilation system. The glovebox system should minimize the potential for release of radioactive material to the environment under normal and abnormal conditions, protect the operators from contamination under normal operating conditions, and mitigate the consequences of abnormal conditions to the maximum extent practical. Where feasible and practical, the glovebox should incorporate passive safety controls rather than active safety controls. In the event that the glovebox is used to process and handle metallic plutonium, it should provide a dry inert atmosphere such as nitrogen or argon to prevent combustion or pyrophoric behavior of the plutonium. Compartmentalization within and between gloveboxes should be considered and installed as necessary to mitigate the potential seriousness of accidents involving fire, explosion, or criticality. The glovebox system design should consider interconnecting tunnels, conveyors, and passageways for transferring materials between adjacent gloveboxes. Provision for containment should be provided.

6.2 *Confinement:*

6.2.1 The glovebox shall be designed to operate at 50 to 500 Pa [0.2 to 2.0 in. H_2O gauge] pressure negative to the room in which it is located. The glovebox and its accessory equipment shall be designed to prevent liquid flooding or subjection of the box to excessive vacuum or pressure. Control devices, such as oil filtered U-tubes to relieve pressure, shall be positive-acting or automatic, or both. See USAEC Report TID 24236.[8] Passive features such as inlet filters, restricted orifices or both shall be considered and sized appropriately.

6.2.2 The glovebox, when assembled and blanked off (evacuated to a given negative pressure and sealed off from further evacuation source), should pass a leak-rate not to exceed 0.3 volume % air/h when tested at an initial pressure differential of one kPa [4 in. H_2O gauge] for 1 h. Penetrations in the glovebox (such as conduits, ports, ducts, pipes, and windows) shall be constructed to prevent the release of

[6] 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.

[7] Available from the American Glovebox Society, P.O. Box 9099, Santa Rosa, CA, 95405, http://www.gloveboxsociety.org.

[8] "Glovebox Window Materials: a Glovebox Fire Safety Application," TID-24896, United States Atomic Energy Commission, Factory Mutual Research Corporation, 1969, http://www.osti.gov/energycitations/servlets/purl/4822006-KYw7jb/.

radioactive material under normal operating conditions. Further test requirements for gloveboxes are defined in AGS-G001-2007 and AGS-G004-2014.

6.2.3 The design of gloveboxes should include means to control and minimize the release of radioactive materials to the plant system during normal plant operation and under a postulated design basis accident.

6.3 *Glovebox Construction*—Gloveboxes should be constructed using appropriate materials and workmanship to ensure confinement and to minimize leakage. The glovebox and support structure should be designed for the heaviest anticipated loading in the glovebox, including such loading factors as pressure differentials, appurtenances, windows, internal equipment, and seismic loading. Combustible materials should be held to a minimum. See AGS-G001-2007 and AGS-G006-2005.

6.3.1 *Materials*—Gloveboxes should be constructed of materials that will be compatible with intended use for structural strength, corrosion resistance, resistance to radiation degradation, and radiation shielding. Gloveboxes should be structurally proof tested at pressures of either 1245 Pa [+5 in. H_2O gauge] or 1.25 times the relief device setting, whichever is greater. The containment structure should be constructed from a minimum of 3.18 mm [0.125 in.] thick 304L or 316L series stainless steel per Specifications A240/A240M and A480/A480M. The interior should be smooth and free of crevices and sharp objects. Internal radii should be compatible with decontamination and radiation monitoring in accordance with AGS standards. Strippable surface coatings may be applied to the interior of the glovebox to facilitate cleaning or decontamination. Surface coatings on the interior of the glovebox may be required for protection when certain acids (hydrochloric, sulphuric, or hydrofluoric) or other corrosive materials are present in the glovebox. Any coatings applied to the interior of the glovebox must be considered as part of the combustible material loads for that glovebox. Glovebox fabrication tolerances should be specified. See USAEC Report TID-24236,[8] USAEC Report TID-16020,[9] and AGS-G001-2007 for options.

6.3.2 *Windows*—Windows should be conveniently located for the worker, and should be constructed of noncombustible or fire-resistant materials that are resistant to mechanical shock and radiation. Gloveboxes intended for the processing and handling of metallic plutonium or uranium should avoid using windows made of plastic or other combustible materials. Laminated glass or a combination of laminated glass and polycarbonate is the preferred construction. The windows shall be securely fastened and should be gasketed or sealed with material that will resist deterioration by chemical attack and radiation degradation, and permit replacement with minimum risk of contamination to the facility. See USAEC Report TID-24896[10] and AGS-G001-2007 for types of material. Window gaskets shall be protected from a fire on both the interior and exterior of the glovebox. An example of a clamped window assembly that minimizes the gasket area exposed to potential fires can be found in AGS-G001-2007.

6.3.3 *Glove Ports*—Glove ports should be designed to allow replacement of gloves without compromising the glovebox atmosphere or contamination control. Ports should be located to facilitate both operating and maintenance work, and take into account the need for two-handed operation, depth of reach, operator comfort from an ergonomic perspective, and positioning with respect to other ports. A detailed dimensional analysis of the operations would assist in eliminating blind spots or inaccessible areas. If glove ports are not used routinely, they shall have glove port plugs and non-combustible glove port covers installed. The plugs should be considered in the design for each glovebox. See AGS-G010-2011.

6.3.4 *Gloves*—Gloves should be chosen on the basis of resistance to possible corrosive atmospheres in the glovebox; resistance to radiation degradation, tearing, and puncturing; and their capability to provide some radiation shielding to the hands. Consideration should be given to high or low temperature sources within the glovebox and their proximity to the gloves. Pinch points and sharp corners should be avoided to the greatest extent possible consistent with ergonomic considerations. Gloves should also be selected on the basis of maintaining maximum dexterity of hand movement. See AGS-G005-2014.

6.3.5 *Internal Configuration*—Consider designing the glovebox with rounded corners and smooth surface finish to avoid areas where plutonium can accumulate. Design equipment and glovebox transfer ports to avoid pinch points, holdup, and loose small parts.

6.4 *Equipment Insertion-Removal*—Bagout ports, sphincter seals, transfer systems, and air locks should be designed and installed to facilitate the introduction or removal of needed equipment without compromising the glovebox atmosphere or contamination controls.

6.5 *Lighting*—323-lx [30 foot candles] lighting should be provided on all surfaces for close work, and 538-lx [50-fc] lighting should be provided for general illumination within the glovebox as viewed from the operator's location. The lighting should be adjusted to compensate for the transmission through the window, glare, reflection, heat, and light intensity prior to going operational. To the maximum extent practical, lighting fixtures should be mounted on the glovebox exterior to facilitate repair and replacement and to avoid the possibility of broken glass within the glovebox. Consideration should be given to lighting systems that minimize power consumption, minimize heat generation, and provide maximum flexibility for maintenance and control, such as LED (light emitting diode) type systems. See AGS-G001-2007.

6.6 *Ventilation:*

6.6.1 The ventilation system should be designed so that its capacity is sufficient to provide and maintain the design negative pressure during normal operation and the design flow through a credible breach during abnormal conditions.

6.6.2 Where the source of combustible solvents, gases, or vapors can be identified or postulated, explosive conditions shall be precluded and suitable monitoring and alarm systems

[9] Garden, Nelson B., et al, AdHoc Committee on Gloveboxes, United States Atomic Energy Commission, Factory Mutual Research Corporation, 1969.

[10] "Glovebox Window Materials," Factory Mutual Research Corp., 1969.

should be installed for control. Electrical systems shall be compatible with potentially flammable atmospheres per the appropriate codes. See NFPA-70 and AGS-G010-2011.

6.6.3 When handling plutonium as an oxide or other basically non-combustible chemical form there shall be exhaust capacity on demand that will promptly cause an inflow of air of 38.1 linear m/min [125 + 25 linear ft/min] through a potential breach of a single glovebox penetration. See AGS-G005-2014 and AGS-G006-2005.

6.6.4 If desired, a portion of the atmosphere may be recirculated within each glovebox, thus lessening the load on heating, cooling, and moisture control equipment. Other glovebox atmospheres may be employed for special uses, such as recirculating dry inert gas for handling pyrophoric or unusually reactive materials such as metallic plutonium. Recirculation systems should be equipped with air-cleaning equipment. Continuous radioactive monitors or samplers may be used to assist in maintaining air quality in such systems.

6.6.5 Filters, scrubbers, demisters, and other air-cleaning devices should be provided to remove excessive moisture, toxic or noxious gases, and airborne particulates exhausted to the ventilation system to levels that are as low as reasonably achievable; requirements should be specified by the user. An easily replaced HEPA filter should be installed at each glovebox atmosphere exit to minimize contamination of duct-work and loading of the final filtration system. A HEPA filter should be installed on the air inlet to the glovebox to preclude the spread of contamination in the event of airflow reversal. Moreover, such filter protection should be extended to the vents of any pressure relief device serving the glovebox. Consider adding a replaceable pre-filter prior to the outlet HEPA filter to capture larger particulates and installing in-place testing ports in accordance with ANSI/ASME AG-1. See USAEC Report TID-24236,[8] USAEC Report TID-16020,[9] and AGS-G001-2007. Location of glovebox and HEPA filters in relation to the room fire suppression sprinklers should be considered.

6.7 *Fire Protection*—Fire protection includes fire detection and suppression. Fire-suppression systems may be omitted where a detailed evaluation shows that fire protection can be provided by the use of a detection system only. The glovebox design shall take into account the fire potential from probable box contents (plutonium metal, organics, sodium, other pyrophoric metals, electrical fixtures, etc.) and should be equipped with a manual or automatic fire suppression system in accordance with NFPA 801 and AGS-G010-2011. The fire suppression and detection system should be located near the exit of the exhaust air stream and other locations as appropriate. The glovebox ventilation inlet and outlet should be equipped with fire screens or flame arrestors to protect the upstream and downstream HEPA filters. The design of the system should be verified by a qualified fire protection engineer or agency. For fire protection, the use of bromotrifluoromethane, CO_2, or other approved fire extinguishing systems should be considered. The potential for excessive gas generation from suppressants and the need to relieve the pressure should be evaluated. See USAEC Report TID-24236[8], AGS-G001-2007, and AGS-G010-2011 for options. Water flooding fire suppression systems should not be installed in Pu gloveboxes. Pressure-relief devices should be installed depending on the results of the evaluation (NFPA 72 and 801).

6.8 *Criticality Prevention*—In all cases where the design provides for the introduction of moderating material (such as water) into a glovebox, suitable drains, overflow devices, or limited volume supply shall be provided to prevent criticality or flooding of the enclosure. The drains shall be protected against plugging and shall drain to a critically safe configuration. This criterion applies where more than a minimum critical mass can be present. Alternatively, an evaluation may be performed to demonstrate that under any credible circumstances a criticality accident could not occur in the event of flooding.

6.9 *Services and Utilities*—Utility services should be designed in a manner that does not compromise radioactive materials confinement, consistent with the potential hazard for all design basis conditions. Any gas supply system connected directly to the box should be designed to prevent flow in excess of exhaust capacity and prevent back flow of contamination. Those services and utilities important to continuity of essential plant function, such as ventilation systems and criticality alarms, should be designed to the same integrity level as the function they serve (AGS-G001-2007).

6.10 *Radiation Shielding*—Personnel radiation exposure limits may require special structural and spatial provisions. Structures should be designed such that, in conjunction with process equipment and associated confinement devices, normal operation and maintenance can be performed quickly and efficiently, thus minimizing radiation exposure. Generally, the majority of radiation exposure from Pu gloveboxes comes from radiation penetrating through the gloves, bagout ports and transfer ports. When not in use, these ports should be shielded to reduce operator exposure. The shielding design should utilize adequate fixed and movable shielding and accommodate hand operation of equipment and the use of handling devices where necessary. Shielding materials should be fire-retardant or noncombustible. Consideration should be given to providing means for the addition of shielding that may be required due to changes in glovebox duty. A time-motion study should be performed with shielding calculations to evaluate personnel exposure. In addition, a reliability, availability, and maintainability study may be performed to determine overall operability limits. This type of study may help maximize overall operability and provide guidance on redundancy features, safety enhancements, and preferred maintenance approaches to minimize worker exposure (10 CFR 20).

6.11 *Waste Systems:*

6.11.1 *Radioactive Liquid Waste*—Sufficient holdup capacity should be provided for the retention of liquid process wastes until they can be analyzed and shown to be within acceptable limits for discharge. In the event that a discharge of liquid wastes to external sumps is provided, liquid traps or seals are necessary to retain ventilation integrity.

6.11.2 *Solid Waste Containing Radioactivity*—Provisions should be made for the safe collection, packaging, storage, removal, and disposal of solid waste generated in the operation