

HRP Training Aid: Gloveboxes

Description	ECCN
Gloveboxes designed for handling radioactive materials	0B999
Protective and detection equipment (e.g., specialized gloves) designed for defense against biological agents or radioactive materials	1A004
Airtight gloveboxes for handling biological materials.....	2B352
Gloveboxes for general laboratory use	EAR99
Gloveboxes – Especially Designed or Prepared (EDP).....	10 CFR Part 110

Key Words and Terminology

Glovebox: A sealed, controlled-atmosphere enclosure used to protect sensitive materials from oxygen/moisture or to shield users from hazardous substances.

- **Note:** Both *glove box* (two words) and *glovebox* (one word) are correct; these terms are used interchangeably.
- **Synonyms:** Isolator, barrier isolator, anaerobic chamber.



Biosafety Cabinet (BSC): An open-front, HEPA-filtered ventilated hood designed to protect users from aerosols and infectious biological agents.

- **Synonyms:** BSC, biological safety hood, bio-hood, Class II/III cabinet.
- **Class III BSC:** A specific type of glovebox designed for maximum biocontainment (export controlled under export control classification number [ECCN] 2B352).
 - A Class III BSC (also known as a *containment isolator*) is specifically engineered for high-risk biological agents and features gastight construction, negative pressure, and HEPA-filtered air.

Key Differences between Gloveboxes and BSCs:

- **Sealing:** Gloveboxes are totally sealed (gastight). BSCs usually have an open-front air curtain.
- **Atmosphere:** Gloveboxes can create inert (N₂, Ar) or dry environments. BSCs use filtered standard room air.
- **Primary Application:** Gloveboxes (chemistry/materials), BSCs (biology/pathogens).

Main Components of a Glovebox

- **Main Chamber:** A large, sealed workspace usually built from materials such as stainless steel or acrylic. The chamber material determines chemical resistance, vacuum capability, and overall durability.
 - **Stainless steel:** Essential for high-purity systems; excellent chemical resistance, easy to clean, very durable; nonporous surface is perfect for achieving low leak rates (e.g., less than 1 ppm).
 - **Aluminum:** Good for general-purpose applications that do not involve harsh materials; a lighter and more affordable option.
 - **Plastics (Acrylic and Polycarbonate):** popular in educational settings or for processes in which high visibility is important; less expensive than stainless steel or aluminum; susceptible to damage from certain solvents; easily scratched.



Stainless steel glovebox



Acrylic glovebox

- **Antechamber (Air lock):** A smaller chamber attached to the main chamber; used for moving materials in or out; ensures that the main workspace stays pure.



A 6 in. glovebox antechamber with doors and a sliding tray

- **Gloves:** Sealed to the glove ports; glove material depends on the material being handled.
 - **Butyl:** Best protection against a wide range of chemicals, especially ketones and esters; highly impermeable to gases.
 - **Neoprene:** Popular all-around option; offers good chemical resistance and is physically tough; more flexible than butyl.
 - **Hypalon (aka chlorosulfonated polyethylene [CSM]):** A premium, high-performance synthetic rubber known for its resistance to oxidizing chemicals, acids, and bases.

- **Gas Purification and Circulation System:** A closed-loop system found on many gloveboxes that continuously flushes the chamber with high-purity gases, such as nitrogen, argon, or helium; moisture and oxygen are reduced to very low levels, creating the environment necessary for handling sensitive substances.



Gas purification unit

Optional Components

- **Advanced Filtration Systems:** Some models include HEPA or ultralow particulate air (ULPA) filters to capture fine particles and ensure a clean working environment.
- **Integrated Monitoring:** Some modern gloveboxes include oxygen and moisture sensors, providing real-time environmental stability.



HEPA filter

Key Applications of Gloveboxes

- **Battery and Energy Storage:** Gloveboxes are essential for assembling lithium-ion batteries and researching next-generation solid-state batteries, because materials in these items react violently with water and oxygen.
- **Chemical Synthesis and Handling:** Gloveboxes are used to handle pyrophoric substances, alkali metals, and other air-sensitive compounds in inert atmospheres (e.g., nitrogen or argon).
- **OLED and Solar Cell Fabrication:** Gloveboxes are used for thin-film deposition, spin coating, and encapsulation of organic electronics and perovskite solar cells; the glovebox environment prevents material degradation.
- **Nuclear Material Handling:** Gloveboxes provide a safe, sealed environment for handling radioactive materials and managing nuclear waste, ensuring operator protection.
- **Pharmaceutical and Biological Research:** Gloveboxes are used for handling hazardous, toxic, or sterile materials (e.g., pathogens) that require negative pressure; they are also used to compound pharmaceuticals.
- **Additive Manufacturing and Welding:** Gloveboxes are used in the 3D printing and laser/tungsten inert gas (TIG) welding of reactive metals (e.g., titanium, aluminum) to prevent oxidation and ensure material integrity.
- **Material Science and Analysis:** Gloveboxes are used for handling, storing, and studying sensitive materials, such as meteorites, or performing microscopy and spectroscopy on samples that degrade in air.

Leading Glovebox Manufacturers

- **MBRAUN**
 - Specializes in high-quality inert gas glovebox systems.
 - Systems are widely used in university and industrial labs for research in emerging technologies such as lithium batteries, chemical processing, and OLEDs.
- **Jacomex**
 - Recognized as a world leader in the design of gloveboxes and isolators for the pharmaceutical and nuclear industries and research and development.
 - Provides both standard and custom-made containment enclosures.
- **Labconco**
 - Prominent manufacturer of laboratory equipment.
 - Product lines include filtered, controlled-atmosphere, and fiberglass models suitable for a variety of laboratory applications.
- **Terra Universal**
 - Leading manufacturer offering a broad array of prebuilt and custom-manufactured glovebox systems.
 - Systems are specifically designed for labs, clean rooms, and research environments, with a focus on contamination control and compatibility with existing clean room setups.
- **Inert**
 - Key supplier of turnkey systems, specializing in high-precision gloveboxes and gas purification units.
 - Extensive custom system development capabilities.
- **Plas-Labs**
 - A leader in manufacturing clear acrylic gloveboxes (popular for general isolation applications), anaerobic chambers, and nitrogen dry boxes.
 - Products are portable, lightweight, and self-contained, suitable for isolating sensitive research from the exterior environment.
- **Coy Laboratory Products**
 - Known for specialized anaerobic and hypoxic chamber gloveboxes.
- **LC Technology Solutions**
 - Focuses on custom-engineered gloveboxes and gas purification systems.
- **Erlab**
 - Provides molecular, filtration-based containment solutions and transportable enclosures.
- **Germfree**
 - Specializes in pharmaceutical-grade isolators and containment systems.

Gloveboxes for Handling Radioactive Materials

ECCN 0B999

This ECCN controls, for anti-terrorism (AT) and regional stability (RS) reasons, specific processing equipment, including item b as follows:

- b.** Glove boxes suitable for use with radioactive materials



Nuclear Glovebox for Handling Radioactive Materials

Features of note:

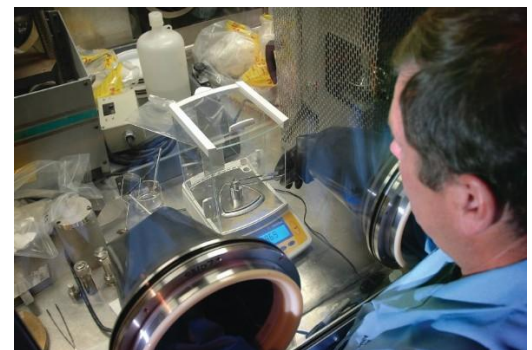
- Rounded corners—essential for inner enclosure cleanup and decontamination
- Interlock system for the antechamber prevents both doors from opening simultaneously
- Bag-in/bag-out outlet filter housings
- Waste bag ports with sealing bags

Specially Designed Gloves

ECCN 1A004

This ECCN controls protective and detection equipment and components not “specially designed” for military use, including item b as follows:

- b.** Protective suits, gloves, and shoes “specially designed” or modified for defense against any of the following:
- b.1.** Biological agents
 - b.2.** Radioactive materials; or
 - b.3.** Chemical warfare (CW) agents



Nuclear glovebox with interior access through the glove ports. Operator is wearing specially designed gloves for protection from contamination.



Gloveboxes for Handling Biological Materials

ECCN 2B352

This ECCN controls equipment capable of use in handling biological materials, including item g as follows:

g.2. Biocontainment chambers, isolators, or biological safety cabinets having *all* the following characteristics, for normal operation:

- g.2.a. Fully enclosed workspace where the operator is separated from the work by a physical barrier
- g.2.b. Able to operate at *negative pressure*
- g.2.c. Means to safely manipulate items in the workspace
- g.2.d. Supply and exhaust air to and from the workspace is high-efficiency particulate air (**HEPA**) filtered.

Note 1: 2B352.g.2 controls **Class III biosafety cabinets**, as specified in the *WHO Laboratory Biosafety Manual* (3rd edition, Geneva, 2004) or constructed in accordance with national standards, regulations, or guidance.

Note 2: 2B352.g.2 controls *any* isolator having all of the characteristics described in 2B352.g.2.a through g.2.d, *regardless of its intended use* and its designation, except for medical isolators “specially designed” for barrier nursing or transportation of infected patients.

Terminology

- **Biocontainment Chamber:** Broad term referring to a specialized, sealed environment for handling high-risk agents.
- **Isolator:** Superior protection; completely sealed, gastight, physical barrier with attached gloves, generally designed for superior sterility and aseptic pharmaceutical processing.
- **Biological Safety Cabinet**
 - Class I/II (excellent protection): Limited by an open front, which allows easier access for manipulating samples (the standard found in many labs).
 - Class III (superior protection): A closed glovebox designed for high-risk infectious agent research.

Note: Positive versus Negative Pressure Systems

The internal pressure of a glovebox is a critical safety feature.

- If an operator needs to shield a sensitive sample from the outside air, *positive pressure* is used. If a small leak occurs, clean gas inside flows out and pushes contaminants away.
- When working with hazardous materials, *negative pressure* is required. If a breach occurs, outside air rushes in instead of hazardous fumes leaking out.

Key Aspects of Gloveboxes Controlled Under ECCN 2B352

• Applications:

- **Anaerobic Gloveboxes (e.g., Bactron300):** Used for creating an oxygen-free environment, often for handling sensitive cultures or chemicals in microbiology labs.
- **Hypoxia Gloveboxes (e.g., Bactrox):** Used for controlling oxygen levels to study cellular responses to low-oxygen environments.
- **BioSafe® Gloveboxes:** Terra Universal produces various stainless steel **BioSafe** gloveboxes for use in pharmaceutical and biomanufacturing applications that fall under ECCN 2B352 controls.
- **Class III Biosafety Cabinets (e.g., SEA-III):** Fully enclosed, gastight systems providing the highest level of containment for working with highly infectious agents.

• Key Features:

- **Construction:** Typically constructed from stainless steel (304 or 316L) with acrylic or glass viewing panels.
- **Containment:** Airtight seals, double-door air locks for sample transfers, and HEPA filtration for inlet/exhaust air.
- **Gloves:** Equipped with sealed, flexible sleeves and gloves (often made from Hypalon/CSM) for operator manipulation of materials.
- **Controls:** Often feature programmable logic control (PLC)- for pressure, temperature, and atmospheric gas level.



Shel Lab Bactron300 Anaerobic Glovebox

- Dimensions: 62.3 x 32 x 27.6 in. (W x D x H)
- Number of glove ports: 2
- Weight: 304 lb
- List Price: \$16,651
- ECCN: 2B352



Shel Lab Bactrox Hypoxia Glovebox

- Dimensions: 49 x 32 x 33 in. (W x D x H)
- Number of glove ports: 2
- Weight: 324 lb
- Exterior material: Finished steel
- Interior material: Stainless steel
- Window material: Acrylic
- List Price: \$26,731
- ECCN: 2B352

Terra Universal BioSafe Glovebox

- Application: Critical pharmaceutical or biological applications with strict sterilization protocols
- Chamber width: 38", 69"
- Chamber depth: 29"
- Chamber height: 39"
- Number of glove ports: 4 as shown (or 2 available)
- Chamber material: 304 or 316 stainless steel
- Window material: Tempered glass
- List Price: \$17K–\$20K
- ECCN: 2B352



Biosafety Cabinet Classes

Biosafety cabinets (BSCs) are divided into three primary classes (I, II, and III) based on their level of protection for personnel, the environment, and products (samples).

Class I BSCs

- Protect the user and the environment from contaminants but do not protect the product inside from room air
- Used for low- to moderate-risk agents
- Use is restricted due to contamination risks; largely replaced by Class II cabinets

Class II BSCs

- Most commonly used BSC type in schools, colleges, and research institutions
- Protect personnel, product, and environment via HEPA-filtered laminar airflow
- Ideal for sterile pharmacy compounding and microbiological work
- Subcategorized as types A1, A2, B1, B2, and C1 based on their construction and exhaust systems

Class III BSCs

- Known as *gloveboxes*
- Gastight; totally enclosed; used for maximum containment (biosafety level 4 [BSL-4]) for safely handling microorganisms



Types of BSCs; only Class III is controlled under ECCN 2B352.



Airstream Class I Biological Safety Cabinet

- Compact size
- Protects the user and the environment
- Suitable for BSL-1 laboratories
- Available size: 4 ft
- Not controlled



LabGard ES AIR NU-543 Class II Type A2 BSC

- Most common type of Class II BSC
- Has a plenum from which 30% of air is exhausted and 70% is recirculated.
- Appropriate for work with agents requiring BSL-1, BSL-2, or BSL-3 containment
- Not controlled



LabGard B1 NU-427 Class II Type B1 BSC

- Has a common plenum from which 70% of air is exhausted and 30% is recirculated
- Suitable for work involving minute quantities of volatile toxic chemicals
- Not controlled



SEA-III Class III BSC

- Application: Sterile drug compounding
- Dimensions: 76 x 25 x 38 in. (W x D x H)
- Number of glove ports: 3
- Weight: 760 lb
- Material: 304 stainless steel
- Window material: Acrylic
- Electrical specifications: 120 V
- ECCN: 2B352

Airstream Class III Biological Safety Cabinet

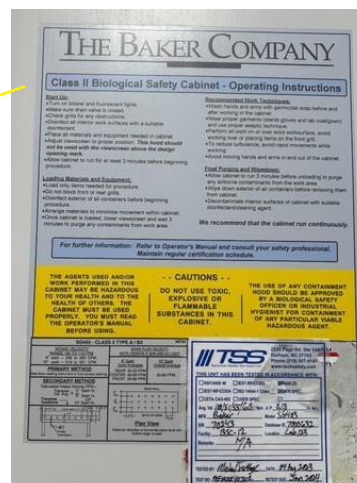
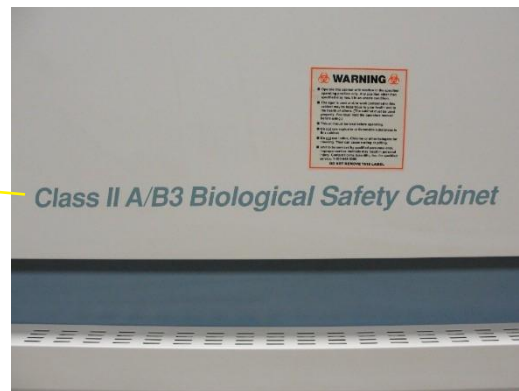
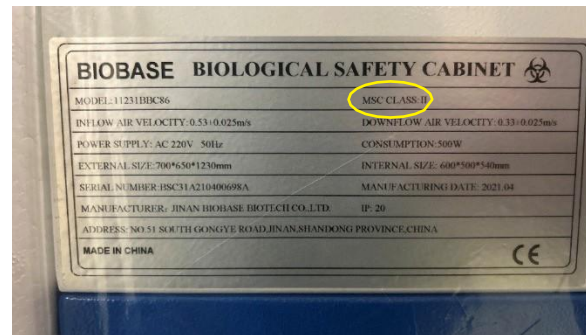
- Dual exhaust HEPA Filter
- Negative pressure work zone
- Monitored by a Magnehelic gauge
- Sentinel Silver Microprocessor controller
- Ergonomically angled front
- Available sizes: 4, 5, and 6 ft
- ECCN: 2B352



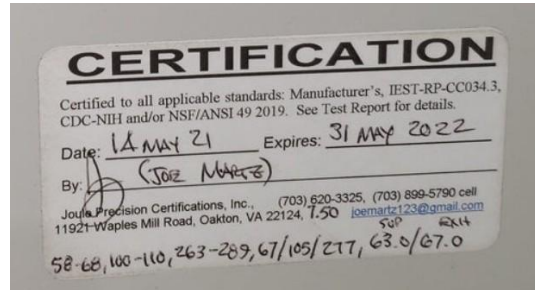
Tips for Identifying Class III BSCs

Features on Nameplates and Labels

- **Classification Identification:** The manufacturer's nameplate or a dedicated label typically includes the cabinet class (e.g., "Class III BSC," "Class III Biological Safety Cabinet").



- **Standards Compliance:** The nameplate may indicate compliance with relevant standards (e.g., designed and tested according to the CDC/NIH guidelines or the Laboratory Safety Monograph [LSM]) for BSL-4 agent containment.



- **Validation and Certification:** Although the nameplate identifies the *type* of cabinet, a separate field certification sticker is usually attached to the front of a unit, displaying the unit's latest testing date, serial number, and confirmation of its gastight integrity.



- **Safety Labels May be Present:**
 - **Biohazard Symbol:** Three crescents circling around a center dot indicate that the equipment is used for handling hazardous biological materials.



Physical Features

- In addition to being recognized based on its nameplate and labels, a Class III cabinet can be identified by its fully welded, gastight construction and attached rubber gloves.

Additional Indicators of Functionality

- Purchase requisitions and orders
- Specifications and drawings
- Operating and maintenance manuals

Gloveboxes for General Laboratory Use

EAR99

Gloveboxes designed for general laboratory use typically include basic, nonspecialized, and low-performance units such as acrylic, PVC, or basic aluminum gloveboxes used for moisture/oxygen reduction or simple containment. These systems often feature manual purging, in contrast to high-performance systems that require sophisticated automated gas purification for extremely low ppm levels.

- **Key Characteristics of General Laboratory Gloveboxes**

- **Materials:** Acrylic (transparent), PVC, or aluminum.
- **Environment:** Typically used with nitrogen or argon to create a low-humidity or anaerobic environment.
- **Application:** General chemical handling, handling of desiccated materials, and protection of samples from environmental contamination.
- **Filtration:** Often equipped with HEPA filters for particle removal.
- **Limitations:** Generally not designed for highly hazardous materials or high-performance, long-term <1 ppm O₂ levels.

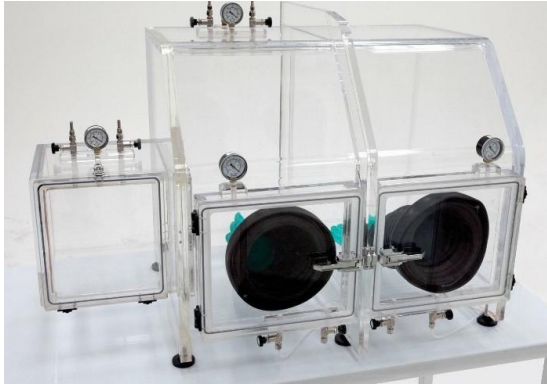
- **General Laboratory use Examples (EAR99):**

- **MSE PRO Economy Compact Acrylic Glove Box:** Ideal for basic laboratory applications.
- **Terra Universal Plastic/Acrylic Glove Boxes:** Basic laboratory isolators suitable for low-humidity and general clean room applications.
- **Cleatech 2100 Series Acrylic Glove Box:** Designed for general-purpose, noncorrosive, inert gas (nitrogen/argon) operations.
- **Labconco Portable/Basic Glove Boxes:** Designed for basic isolation or containment; optional HEPA filtration.
- **Plas-Labs 810/830/815 Series “Basic” or “University” gloveboxes:** Provide fully sealed environments for general research.



MSE PRO Economy Compact Laboratory Acrylic Glovebox

- Two ports with an air lock chamber for controlling moisture and oxygen
- List Price: \$3,200
- ECCN: EAR99



Terra Universal Plastic/Acrylic Glovebox

- Series 210
- Negative pressure exhaust
- Left-side air lock
- Dimensions: 35.5 x 27 x 30 in. (W x D x H)
- Number of glove ports: 2
- List Price: \$5,576
- ECCN: EAR99

Cleatech 2100 Series Acrylic Glovebox

- Number of glove ports: 2
- Material: 0.25 in. thick clear or static-dissipative acrylic
- List Price: \$1,680
- ECCN: EAR99



PLAS LABS "University" Glovebox, Model 810-SG40

- Provides a fully sealed environment for general research
- Transfer chamber with purging valves and vacuum gauge
- Pressure relief valve with small HEPA canister
- Dimensions: 76 x 32 x 35 in. (W x D x H)
- List Price: \$12,190
- ECCN: EAR99



Bel-Art Portable Glovebox

- Lightweight, self-contained, portable isolation cabinet provides operator protection
- Dimensions: 27 x 13 x 22 in. (L x W x H)
- Glove ports: 6 in. circular glove ports; 8 in. diameter side port
- Weight: 25.2 lb
- Materials: LDPE (thermoplastic) body; acrylic window; neoprene gloves
- List Price: \$2,266
- ECCN: EAR99

Gloveboxes Especially Designed or Prepared (EDP)

10 CFR Part 110

Gloveboxes especially designed or prepared (EDP) for the processing, use, or production of special fissionable material (e.g., plutonium-239; uranium-233; uranium enriched in isotopes 235 or 233) are subject to the export licensing authority of the Nuclear Regulatory Commission (NRC) (see 10 CFR Part 110).

Key equipment items, including gloveboxes, are needed to protect against special radiological, toxicity, and criticality hazards associated with the processing of uranium or plutonium. Such items are typically not available off the shelf; rather, they must be especially designed or prepared to meet certain requirements and specifications.

For example, these requirements include the following:

- Appendix O to 10 CFR Part 110, “Illustrative List of Fuel Element Fabrication Plant Equipment and Components Under NRC’s Export Licensing Authority”
- Appendix J to 10 CFR Part 110, “Illustrative List of Uranium Conversion Plant Equipment and Plutonium Conversion Plant Equipment Under NRC Export Licensing Authority”



Left: Workers using gloveboxes to handle plutonium.

Right: Criticality safe vessel (slab tank) visible through the glass panel of a glovebox.

