Cytotoxic Drugs

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Introduction

Cytotoxic drugs include any drug that inhibits or prevents the function of cells. Cytotoxic drugs include drugs used to treat cancer and in some cases, to treat certain skin conditions (e.g., psoriasis).
This guide explains the duty of an employer in a health care facility to protect workers who are likely to be exposed to cytotoxic drugs. Such worker exposure may occur at health care facilities such as hospitals, Special Care and Personal Care Homes, cancer and other medical clinics, and in home care situations.

Reasons for concern

There has been a considerable increase in concern over the potential of cytotoxic drugs to harm workers who are likely to be exposed to them. This includes workers who prepare, administer, or handle the drugs.
The concern is based on:

- toxic side effects seen in patients treated with these drugs
- evidence that these drugs can produce chromosome changes, cancer, and reproductive abnormalities in animal experiments
- adverse effects in workers exposed to them

When therapeutic doses are given to patients, cytotoxic drugs produce toxic side effects due to their poor selectivity between target (e.g., cancer cells) and normal cells.
There is ample evidence that many of these drugs cause serious adverse effects in cancer patients receiving long-term therapy. These adverse effects include:

- neoplasms and leukemias
- testicular and ovarian dysfunction — including permanent sterility
- cumulative chromosome damage
- other organ damage

Animal studies confirm the potential of these agents to induce malignancy and to cause chromosomal damage and reproductive abnormalities. *Appendix 1* lists antineoplastic or anti-cancer drugs that

have been classified by the International Agency for Research on Cancer (IARC) as possible or probable cancer-causing agents.
Not all cytotoxic drugs are carcinogenic. In particular, antimetabolites such as methotrexate (amethopterin), cytarabine (cytosar), and 5-fluorouracil (5-FU) have not caused cancer in animal studies or in humans receiving therapeutic treatments, despite their use by a large number of patients over many years. On the other hand, the alkylating agents (in particular nitrogen mustards, ethylenimine derivatives, and nitrosoureas) have been shown repeatedly to be carcinogenic in laboratory systems and in cancer patients.
Studies of worker exposure to cytotoxic drugs have shown:

- detectable levels of cytotoxic drugs in the air of hospital areas where parenteral cytotoxic drugs are prepared without the use of biological safety cabinets (BSC)

- detectable amounts of various cytotoxic drugs in the urine of health care workers preparing the drugs without adequate precautions

There is also evidence that exposure to cytotoxic drugs can cause adverse effects in workers. There are reports that exposure to cytotoxic drugs:

- can cause an increased frequency of chromosome damage in exposed workers

- can produce some acute effects in workers which include skin, eyes, and mucous membrane irritations, allergic reactions upon contact with the skin, as well as subjective symptoms including nausea, headache, and dizziness

- has been associated with adverse reproductive outcomes (including higher incidences of spontaneous abortions and a higher risk of delivering malformed babies)

Repeated, long term occupational exposure to small amounts of cytotoxic drugs has not been identified as a cause of cancer. However, because of the above mentioned concerns, precautions must be followed to limit occupational exposure to all cytotoxic drugs.

Sources of exposure

Worker exposure occurs by inhalation of drug dust or aerosol, absorption through the skin, and ingestion through contact with contaminated food, drink, or cigarettes. The aerosol is generated during the preparation or the administration of the drug, (e.g., while

breaking open ampules, withdrawing needles from drug vials, transferring drugs with syringes, or expelling air from a drug-filled syringe). Such aerosol can result in exposing not only the worker immediately involved, but also exposing other people in the surrounding areas. Workers may also be exposed to cytotoxic drugs when they handle contaminated equipment and supplies.

Responsibilities for controlling exposure

Section 471 of *The Occupational Health and Safety Regulations, 1996,* requires employers in health care facilities to take all practicable steps to minimize worker exposure to cytotoxic drugs or materials, or equipment contaminated with cytotoxic drugs. [1]

Where workers are required to prepare, administer, handle, or use cytotoxic drugs or are likely to be exposed to them, the employer must prepare and implement a **written program**. The program includes written procedures and other precautions to ensure the health and safety of workers. The employer must train workers on the content of the program and its procedures when implementing the program.

Where workers prepare *parenteral* cytotoxic drugs on a **frequent and continuing** basis, the employer must provide and maintain an **approved** biological safety cabinet (BSC) and ensure it is used safely.

The regulations also place duties on workers to co-operate with the employer and use the safe work procedures and protective equipment referred to in the written program.

[1] **"Practicable"** means physically possible in the light of current knowledge and invention.

Guidelines for controlling exposures

The following guidelines explain the employer's duties under section 471 of the regulations and are intended to assist the employer in developing the written program.

The written program

The occupational health committee must be consulted in developing the written program. The program must address the following issues:

1 How cytotoxic drugs, supplies, and equipment contaminated with cytotoxic drugs will be:

   a) identified

   b) stored

   c) prepared, transported, administered, handled, and used (including means to reduce aerosolization)

   d) disposed of — This section must identify a means to contain and label cytotoxic drug wastes. It should also describe how the wastes will be transported according to Transportation of Dangerous Goods Regulations and identify the collection or disposal site (which must be approved by Saskatchewan Environment and Resource Management [SERM] to handle cytotoxic wastes).

2 Emergency procedures to use:

   a) when a cytotoxic drug spills or leaks, (e.g., from a damaged package) or

   b) when a worker is exposed to cytotoxic drugs as a result of:

      - a skin puncture
      - contact with intact skin
      - contact with the eye
      - accidental inhalation of drug dust or aerosol, or
      - swallowing a substance contaminated with a cytotoxic drug

3 How equipment that becomes contaminated with cytotoxic drugs will be maintained or disposed of.

4 The use of:

   a) engineering controls (e.g., general or local exhaust ventilation)

   b) work practices

   c) hygiene practices (e.g., personal hygiene standards). These standards should include a ban on eating, drinking, smoking, applying cosmetics, or storing food in or near the preparation area

   d) hygiene facilities (such as personal wash facilities)

   e) approved respiratory protective devices, approved eye or face protectors, and other appropriate personal protective equipment

   f) decontamination materials and equipment that are appropriate in the circumstances

5 The use of an approved BSC for preparing cytotoxic drugs and methods of maintaining the cabinet.

Once prepared, the program must be implemented. Workers must be trained on the program and a copy of the program must be made available to them for their reference.
The following sections describe protective measures to minimize workers' exposure.

Preparation of parenteral cytotoxic drugs

Before preparing the written program, determine whether the facility will be equipped to prepare parenteral cytotoxic drugs.
The employer must make a determination of whether the health care facility will prepare parenteral cytotoxic drugs on a **frequent and continuing** basis. To make this determination, the employer needs to examine the present situation at the facility considering the size of the population being served, the size of the facility, how frequently parenteral cytotoxic drugs have been prepared in the past, and the location of the nearest facility that has an approved BSC. The employer should also consider any intended changes to the current situation. For example, are there any intended changes in the size of the population being served or other reasons that might increase the frequency of cytotoxic (parenteral) drug preparations?
Where the determination is made that parenteral cytotoxic drugs will be prepared on a frequent and continuing basis in the facility, an **approved BSC** must be provided to workers. Where this is not the case, the employer must make this intention clear to the occupational health committee and the workers, and should also explain to clients what the alternate arrangements are.
An alternative arrangement may be made with another facility. These drugs could be prepared at a nearby facility that has an approved BSC and then transported to the facility where the drugs will be administered to patients. Other alternatives should also be considered. For example, the patient may travel to another nearby health care facility that is suitably equipped to prepare parenteral cytotoxic drugs.
Parenteral cytotoxic drugs may be prepared on an occasional or interim basis at a health care facility that does not have an approved BSC, where:

- exceptional circumstances arise
- alternative arrangements prove impractical to use, or
- the employer has planned for, but not yet received, the BSC

In such cases, the employer must determine what arrangements can be made in the facility to minimize worker exposure to parenteral cytotoxic drugs being prepared. The arrangement must include measures to protect the worker preparing the drug, other workers in the vicinity, and prevent the spread of drug contamination from the immediate vicinity of the preparation area.

Approved Biological Safety Cabinets (BSC)

Class II BSC: B1, B2, or B3; and Class III BSC that meet the current National Sanitation Foundation Standard No. 49 (See the *Resources*

section) are **approved** for the purposes of preparing parenteral cytotoxic drugs. (See *Appendix 2* for descriptions and diagrams of the various Class II BSC.)

Class II Type A BSC exhaust HEPA-filtered cabinet air into the workroom. They are also **approved** if:

A. They are used with a canopy or thimble hood that captures air released from the BSC and exhausts the air out of the building; or
B. There are means to ensure that the HEPA filter is functioning effectively before each use (e.g., by reading a properly installed pressure differential gauge) and the exterior surface of the HEPA filter is protected from damage. (Option A is recommended instead of this approach.)

Preference should be given to Type B-BSC, which does not exhaust any cabinet air into the workroom.

See the *Resources* section for more information on BSC.

Using and maintaining the Biological Safety Cabinet

The BSC must be inspected and certified by a competent person at least annually and when the cabinet is moved. See the *Resources* section for example agencies that provide this service in the province.

The BSC must be cleaned, maintained, and used according to the manufacturer's recommendations.

The exhaust blower on the BSC should be operated continuously — even when not in use.

The cabinet should be cleaned daily with 70 percent alcohol and decontaminated weekly or whenever spills occur. Decontamination should consist of surface cleaning with an alkaline detergent followed by thorough rinsing. Personal protective equipment as described later in this document should be used while decontaminating the cabinet.

The ductwork attached to the cabinet should be labelled as to its hazardous content.

Where the Biological Safety Cabinet is not required

A centralized area for the preparation of cytotoxic drugs should be designated. The area should be a work area that is quiet, uncluttered, and well ventilated. The ventilation system, fans or air conditioning unit should not blow air directly at the preparation area. The area should be clearly posted with a sign identifying it as a cytotoxic drug preparation area.

Respiratory protection

Approved respiratory protection must be provided by the employer and worn by workers who may be exposed to cytotoxic drug dusts or aerosols. This type of exposure may occur when workers:

- prepare cytotoxic drugs on a counter or some other place that is outside of an approved BSC
- clean up spilled cytotoxic drugs
- decontaminate a BSC that has the sash raised

Approved respiratory devices

Approved respiratory protective devices include a reusable facemask with filter cartridges, or a disposable filter mask. The filter cartridges or the filter mask must provide high efficiency particulate air (HEPA) filtration and carry the National Institute for Occupational Safety and Health (NIOSH) label with either the N100, P100, or R100 rating.

These respirators are available from most safety equipment suppliers. Surgical masks are neither suitable nor adequate to protect the worker.

Use and maintenance of respirators

Workers should be trained to use their respirator properly. Training should include how to ensure a proper fit and prevent the contamination of the inner surface of the respirator. Reusable facemasks should be cleaned and inspected after each day's use. The cartridge should be replaced according to manufacturer's recommendations. When not in use, respirators should be stored in a dust-proof, sanitary location.

Other personal protective equipment

Personal protective equipment should be provided for and used by workers preparing or administering the drugs. The equipment should include well-fitted disposable gloves, an appropriate protective gown, and eye protection.

Gloves

Thicker gloves provide better protection, as cytotoxic drugs can permeate most glove materials — including latex. Non-powdered gloves are preferred because powders adsorb the drugs. Powdered latex gloves also adsorb latex proteins. Workers who use powdered latex gloves are exposed to more of the latex proteins that cause latex allergy in some persons. Workers who have developed an allergy to latex proteins must be provided with vinyl or nitrile gloves or glove liners.

Protective gown

A gown made of low permeability fabric with a closed front, long sleeves, and closed cuffs is recommended.

Eye protection

Eye protection, such as splash goggles, should be made available for use in any situation where there is a risk of splashes into the eyes. Eye protection should also be used when cleaning up spills.

Use of personal protective equipment

- Gloves should be routinely changed approximately every hour or immediately if they are torn or punctured. Double gloving is recommended for cleaning up spills.
- Potentially contaminated gowns or gloves should not be worn outside the work area.
- Hands must be washed before and after gloving.
- If an accidental spill or splash occurs, contaminated clothing should be removed immediately and contaminated skin or eyes should be flushed immediately with copious amounts of running water to effectively cleanse the area.

Supplies and equipment for drug preparation, administration, and waste disposal

Suitable preparation, administration, and waste disposal supplies and equipment must be made available to the workers. These include:

- disposable, absorbent, plastic backed sheeting to cover the work area and potential leakage areas
- equipment to vent reconstituted vials to reduce internal pressure and potential for spillage or liquid spraying when a needle is withdrawn from the vial septum (e.g., a disposable needle and a 0.2 μm hydrophobic filter unit, such as the Millex Vial Vent Unit)
- syringes and intravenous sets with Luer-lock fittings
- disposal collection containers such as a plastic or metal tray lined with sterile gauze to collect excess solution
- closable, puncture-resistant, labelled containers for disposal of contaminated sharp or breakable materials
- labelled, sealable or wiretie plastic bags of sufficient thickness (4 mil thick polyethylene or 2 mil polypropylene) for the collection of waste including used gloves, paper liners, used disposable gowns, unused pills, powder residues and containers, and used gauze and alcohol wipes
- spill cleaning material including absorbent gauze pads, spill control pillows, and a small scoop to collect glass fragments
- sterile gauze pads to surround ampoules before breaking them open

Work procedures

Written safe work procedures or specific instructions are a part of the written plan. They should be formulated or otherwise adapted from existing written/published procedures. The employer must implement and train workers on the procedures and make them available to all personnel involved in the mixing and/or administration of the drugs. There are several written/published procedures available — Saskatchewan Cancer Agency Guidelines, the U.S. Occupational Health and Safety Administration Guidelines, Canadian Society of Hospital Pharmacists Guidelines, the American Pharmaceutical Society Guidelines, etc. One or more of these documents should be obtained and adapted to the workplace (See the *Resources* section).

Training

The employer must ensure workers are:

- informed of the hazards of cytotoxic drugs and risks of exposure
- instructed on proper precautions
- trained on safe work procedures
- supervised to make sure they follow safe work procedures

Pre-job training must be given to all personnel involved in the mixing and/or administration of cytotoxic drugs.

The training must include housekeeping, laundry, and janitorial staff. They must receive training on the potential hazards of handling laundry, excreta, etc., contaminated with cytotoxic drugs, and safe work procedures when handling these materials.
The training should be continually assessed and reinforced.[2]
The written program must address how training will be developed, delivered, and evaluated.

[2] **"Train"** means to give information and explanation to a worker with respect to a particular subject-matter and require a practical demonstration that the worker has acquired knowledge or skill related to the subject-matter.

Additional protection for pregnant workers

A pregnant worker who may be exposed to hazardous amounts of cytotoxic drugs may notify the employer that she is pregnant. In this situation, the employer must minimize this worker's exposure (section 308 of the regulations). If this is not *reasonably practicable*, the employer must transfer a pregnant worker, on the worker's request, to duties that do not involve handling cytotoxic drugs, where such duties are available.[3]

A policy covering male or female personnel who are actively trying to conceive a child and breast-feeding workers should also be established.

[3] **"Reasonably practicable"** means practicable unless the person on whom a duty is placed can show that there is a gross disproportion between the benefit of the duty and the cost, in time, trouble and money, of the measures to secure the duty.

Resources

1 Controlling Occupational Exposure to Hazardous Drugs. Occupational Safety and Health Administration CPL 2-2.20B CH-4. Chapter 21. OSHA Publications. PHONE: (202) 219-4667.

2 Guidelines for the Handling and Disposal of **Hazardous Pharmaceuticals** (Including Cytotoxic Drugs) 1997. Canadian Society of Hospital Pharmacists. Ottawa, Ontario. PHONE: (613) 736-9733.

3 Guidelines for the Safe Handling and Disposal of Antineoplastic Drugs in Saskatchewan. The Saskatchewan Cancer Agency. Revised 1996-7. PHONE: (306) 585-1831.

4 Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets. Center for Disease Control and Prevention and The National Institute of Health. PHONE: (404) 639-3311.

5 Safe Handling of Cytotoxic and Hazardous Drugs. The American Society of Health System Pharmacists. PHONE: (301) 657-3000.

6 Safe Handling of Cytotoxic Drugs in Home Chemotherapy. Seminars in Oncology Nursing (502), Suppl. 1, 1989, pp 15-20.

7 Standard No 49 for Class II (Laminar Flow) Biohazard Cabinetry. The National Sanitation Foundation (NSF) International PHONE: (313) 769-8010.

8 BSC Certification:

Richard White
Biological Safety
Toxicology Research Centre
University of Saskatoon
Saskatoon, SK
S7N 5B3
PHONE: (306) 966-8496

BGE Service and Supply Limited
5711 – 103 A Street
Edmonton, Alberta
T6H 2J6
PHONE: (403) 436-6960

Appendix 1: Antineoplastic drugs classified by the International Agency for Research on Cancer (IARC)

Antineoplastic or anti-cancer drugs are used to treat cancer. Most antineoplastic drugs are also cytotoxic.
The following is a list of antineoplastic drugs that have been classified by the International Agency for Research on Cancer (IARC) as known, probable, or possible **cancer-causing agents**.
It is not a complete listing of all carcinogenic antineoplastic drugs, since not all antineoplastic drugs have been reviewed and classified by IARC.
Some of the following antineoplastic drugs that are classified as potentially carcinogenic are not cytotoxic. Despite this, the precautions outlined in this guide and guides on antineoplastic drugs should be used.

Group 1 – Drugs which are carcinogenic (sufficient human evidence of carcinogenesis)[4]

- Azathioprine (Imuran)
- Busulfan (Myleran)
- Certain combined chemotherapy for lymphomas:
  (e.g., procarbazine, vincristine, prednisone, and nitrogen mustard)
- Chlorambucil (Leukeran)
- Cyclophosphamide (Cytoxan, Procytox)
- Melphalan (Alkeran)
- Thiotepa
- Tamoxifen citrate (Apo-Tamox, Gen-Tamoxifen, Nolvadex, Nolvadex-D, Novo-Tamoxifen, Tamofen, Tamone)
- Diethylstilbestrol sodium diphosphate (Honvol)

[4] Source: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Supplement 7, 1987.

Group 2A – Drugs which are probably carcinogenic to humans (generally, limited human evidence, but sufficient animal evidence)[5]

- Bischloroethyl nitrosourea or carmustine (BiCNU)
- 1-(2-chloroethyl)-3-cyclohexyl-1-nitrosourea or lomustine (CeeNU)
- Cisplatin (Platinol)
- Doxorubicin (Adriamycin)
- Nitrogen mustard (Mustargen)
- Procarbazine (Natulan)
- Methoxsalen, plus UV radiation (Oxsoralen, Oxsoralen-Ultra, UltraMOP)

Group 2B – Drugs which are possibly carcinogenic to humans (generally, limited human evidence, but absence of animal evidence)[6]

- Bleomycin sulfate (Blenoxane)
- Dacarbazine (DTIC)
- Mitomycin (Mutamycin)
- Streptozocin (Zanosar)
- Daunorubicin (Cerubidine)
- Medroxyprogesterone acetate (Alti-MPA, Depo-Provera, Provera)–cancer, hormone

[5] Source: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Supplement 7, 1987.

[6] IBID.

Drugs with evidence of carcinogenicity which, at present, are not used clinically in Canada

- Chlornaphazine (Group 1)
- 1-(2-chloroethyl)-3-(4-methylcyclohexyl)-l-nitrosourea or Methyl-CCNU (Group 1)
- Treosulphan (Group 1)
- Aminouracil mustard or Uracil mustard (Group 2B)
- Nitrogen mustard, n-oxide (Group 2B)
- Azacitidine (Group 2A)
- Chlorozotocin (Group 2A)
- Trichlormethine (Group 2B)

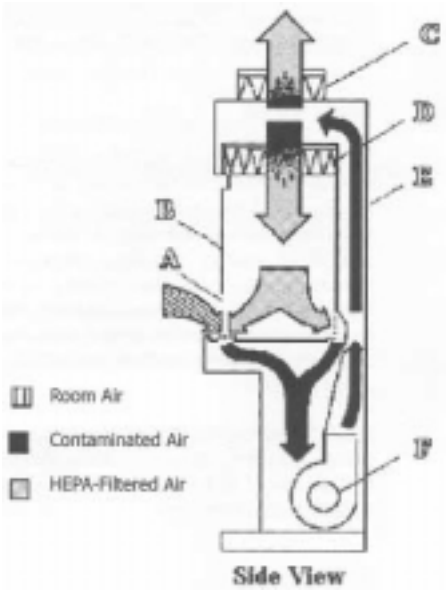
Appendix 2: Class II and Class III Biological Safety Cabinets

Excerpts from Primary Containment for Biohazards. Selection, Installation and Use of Biological Safety Cabinets. Centre for Disease Control and Prevention and National Institutes of Health. 1995.

Class II BSC

The Class II (Types A, Bl, B2, and B3) biological safety cabinets provide personnel, environmental, and product protection. Air flow is drawn around the operator into the front grille of the cabinet, which provides personnel protection. In addition, the downward laminar flow of HEPA-filtered air provides product protection by minimizing the chance of cross-contamination along the work surface of the cabinet. Because cabinet air has passed through the exhaust HEPA filter, it is contaminant-free (environmental protection), and may be recirculated back into the laboratory (Type A BSC) or ducted out of the building (Type B BSC).
HEPA filters are effective at trapping particulates and infectious agents, but not at capturing volatile chemicals or gases. Only BSCs that are ducted to the outside should be used when working with volatile toxic chemicals.

The Class II, Type A BSC



A. front opening
B. sash
C. exhaust HEPA filter
D. supply HEPA filter
E. rear plenum
F. blower

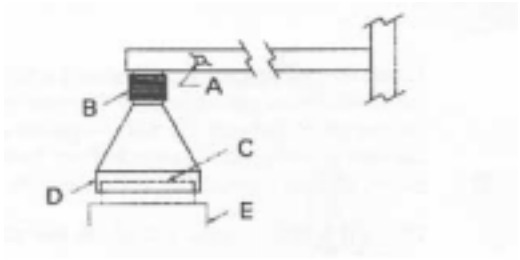
An internal blower draws sufficient room air through the front grille to maintain a minimum calculated or measured average inflow velocity of at least 75 lfpm at the face opening of the cabinet. The supply air flows through a HEPA filter and provides particulate-free air to the work surface. Laminar airflow reduces turbulence in the work zone and minimizes the potential for cross-contamination.

The downward moving air "splits" as it approaches the work surface; the blower draws part of the air to the front grille and the remainder to the rear grille. Although there are variations among different cabinets, this split generally occurs about halfway between the front and rear grilles, and two to six inches above the work surface.

The air is then discharged through the rear plenum into the space between the supply and exhaust filters located at the top of the cabinet. Due to the relative size of these two filters, approximately 30 percent of the air passes through the exhaust HEPA filter and 70 percent recirculates through the supply HEPA filter back into the work zone. Most Class II, Type A cabinets have dampers to modulate this 30/70 division of airflow.

An unducted Class II Type A BSC is not to be used for work involving volatile or toxic chemicals. The buildup of chemical vapors in the cabinet (by recirculated air) and in the laboratory (from exhaust air) could create health and safety hazards.

It is possible to duct the exhaust from a Type A cabinet out of the building. However, it must be done in a manner that does not alter the balance of the cabinet exhaust system, thereby disturbing the internal cabinet airflow. The typical method of ducting a Type A cabinet is to use a "thimble," or canopy hood, which maintains a small opening (usually one inch) around the cabinet exhaust filter housing. The volume of the exhaust must be sufficient to maintain the flow of room air into the space between the thimble unit and the filter housing (contact manufacturers for any additional specifications). The thimble must be removable or be designed to allow for operational testing of the cabinet. The performance of a cabinet with this exhaust configuration is unaffected by fluctuations in the building exhaust system.



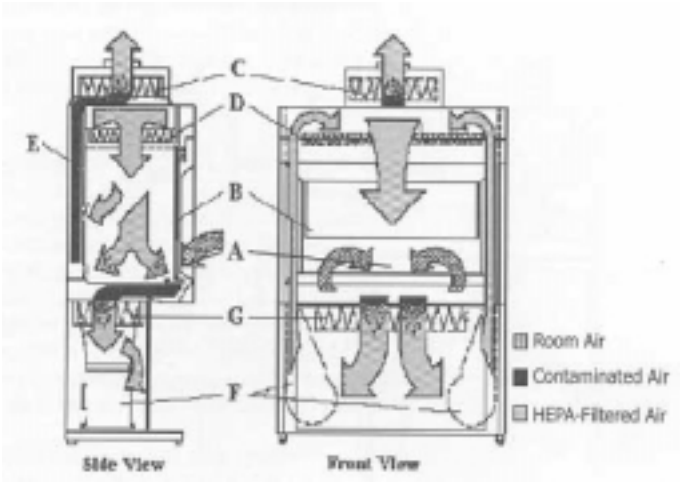
Thimble unit for ducting a Class II, Type A BSC.

Note: There is a one inch gap between the thimble unit (D) and the exhaust filter housing (C), through which room air is exhausted.

A. balancing damper
B. flexible connect to exhaust system
C. cabinet exhaust HEPA filter housing
D. thimble unit
E. BSC

"Hard-ducting" (i.e., direct connection) of Class II Type A cabinets to the building exhaust system is not recommended. The building exhaust system must be precisely matched to the airflow from the cabinet in both volume and static pressure. However, fluctuations in air volume and pressure that are common to all building exhaust systems make it difficult, if not impossible, to match the airflow requirements of the cabinet.

The Class II, Type B1 BSC



Connection to building exhaust system required.

A. front opening
B. sash
C. exhaust HEPA filter
D. supply HEPA filter
E. negative pressure exhaust plenum
F. blower
G. additional HEPA filter for air supply

Note: The cabinet exhaust must be connected to the building exhaust.

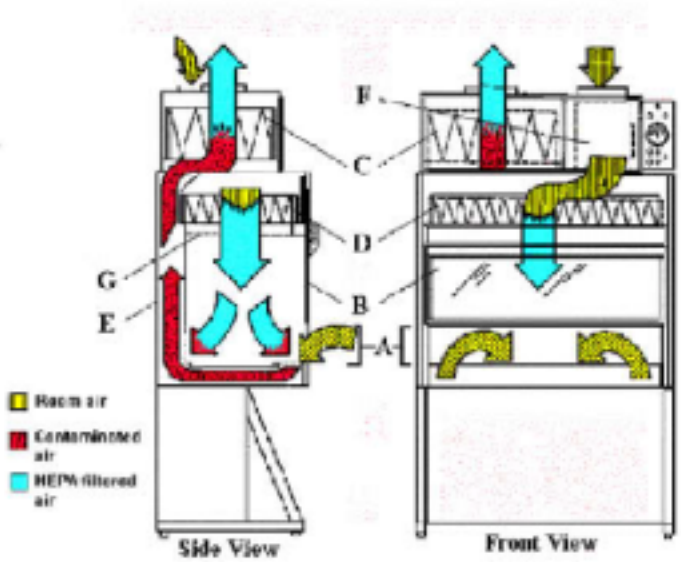
The cabinet supply blowers draw room air (plus a portion of the cabinet's recirculated air) through the front grille and then through the supply HEPA filters located immediately below the work surface. This particulate-free air flows upward through a plenum at each side of the cabinet and then downward to the work area through a backpressure plate. In some cabinets there is an additional supply HEPA filter to remove particulates that may be generated by the blower/motor system.

Room air is drawn through the face opening of the cabinet at a minimum inflow velocity of 100 lfpm. As with the Type A cabinet, there is a split in the down-flowing air stream just above the work surface. In the Type B cabinet, approximately 70 percent of the downflow air exits through the rear grille, passes through the exhaust HEPA filter, and is discharged from the building. The remaining 30 percent of the downflow air is drawn through the front grille. Since the air which flows to the rear grille is discharged into the exhaust system, activities that may generate hazardous chemical vapors or particulates should be conducted towards the rear of the cabinet

Type Bl cabinets must be hard-ducted, preferably to their own dedicated exhaust system, or to a properly designed laboratory building exhaust. As indicated earlier, blowers on laboratory exhaust systems should be located at the terminal end of the duct work. A failure in the building exhaust system may not be apparent to the user, as the supply blowers in the cabinet will continue to operate. A pressure-independent monitor should be installed to sound an alarm and shut off the BSC supply fan should failure in exhaust airflow occur. Since this feature is not supplied by all cabinet manufacturers, it is prudent to install a sensor in the exhaust system as necessary. To maintain critical operations, laboratories using Type B BSCs should connect the exhaust blower to the emergency power supply.

The Class II, Type B2 BSC

Connection to building exhaust system required.



A. front opening
B. sash
C. exhaust HEPA filter
D. supply HEPA filter
E. negative pressure exhaust plenum
F. supply blower
G. filter screen

Note: The carbon filter in the building exhaust is not shown. The cabinet exhaust must be connected to the building exhaust system.

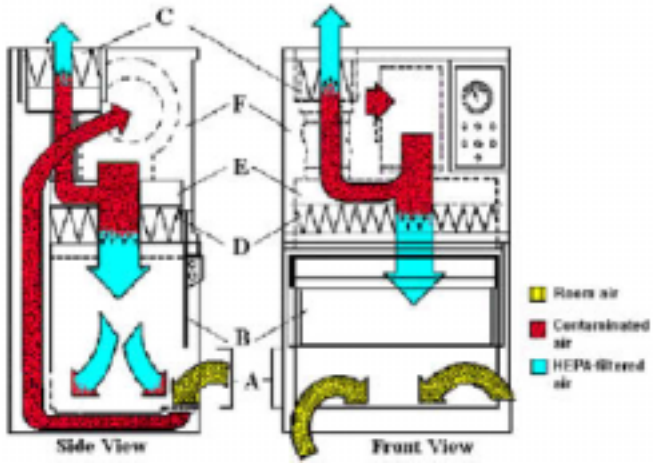
This BSC is a total-exhaust cabinet; no air is recirculated within it. This cabinet provides simultaneous primary biological and chemical containment. The supply blower draws in room air or outside air at the top of the cabinet, passes it through a HEPA filter and down into the work area of the cabinet. The building or cabinet exhaust system draws air through both the rear and front grilles, capturing the supply air plus the additional amount of room air needed to produce a minimum calculated or measured inflow face velocity of 100 lfpm. All air entering this cabinet is exhausted and passes through a HEPA filter (and perhaps some other air-cleaning device such as a carbon filter) prior to discharge to the outside. Exhausting as much as 1200 cubic feet per minute of conditioned room air makes this cabinet expensive to operate.

Should the building or cabinet exhaust fail, the cabinet will be pressurized, resulting in a flow of air from the work area back into the laboratory. Cabinets built since the early 1980's usually have an interlock system installed by the manufacturer to prevent the supply blower from operating whenever the exhaust flow is insufficient. The

presence of such an interlock system should be verified so systems can be retrofitted if necessary. Exhaust air movement should be monitored by a pressure-independent device.

The Class II, Type B3 BSC

Connection to building exhaust system required.



A. front opening
B. sash
C. exhaust HEPA filter
D. supply HEPA filter
E. positive pressure plenum
F. negative pressure plenum

Note: The cabinet exhaust must be connected to the building exhaust system.

This biological safety cabinet is a ducted Type A cabinet having a minimum inward airflow of 100 lfpm. All positive pressure contaminated plenums within the cabinet are surrounded by a negative air pressure plenum, so leakage in a contaminated plenum will be into the cabinet and not into the environment.

The Class III BSC

The Class III biological safety cabinet was designed for work with biosafety level 4 microbiological agents and provides maximum protection to the environment and the worker. It is a gas-tight enclosure with a non-opening view window. Access for passage of materials into the cabinet is through a dunk tank (accessible through the cabinet floor) or double-door pass-through box (such as an autoclave) that can be decontaminated between uses. Reversing that process allows for safe removal of materials from the Class III biosafety cabinet. Both supply and exhaust air are HEPA-filtered. Exhaust air must pass through two HEPA filters, or a HEPA filter and an air incinerator, before discharge to the outdoors. Airflow is maintained by a dedicated, independent exhaust system exterior to the cabinet, which keeps the cabinet under negative pressure (usually about 0.5 inches of water pressure).

Long, heavy-duty rubber gloves are attached in a gas-tight manner to ports in the cabinet and allow for manipulation of the materials isolated inside. Although these gloves restrict movement, they prevent the user's direct contact with the hazardous materials. The trade-off is clearly on the side of maximizing personal safety. Depending on the design of the cabinet, the supply HEPA filter provides particulate-free, albeit somewhat turbulent, airflow within the work environment.