Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

CONTAINMENT STANDARDS FOR FACILITIES HANDLING PLANT PESTS

DRAFT

Biohazard Containment and Safety Unit
Science Branch
Canadian Food Inspection Agency

Canada

These standards were developed by a Working Group of experts from the Canadian Food Inspection Agency, Agriculture and Agri-Food Canada and McGill University. Their advice, expertise and input are gratefully acknowledged.

Working Group Members

Craig Armitage
Chief, Planning, Design and Construction,
Business Planning
Canadian Food Inspection Agency
159 Cleopatra Dr.
Ottawa, ON
K1A 0Y9

Carolyn Babcock
Curator,
Canadian Collection of Fungal Cultures
Agriculture and Agri-Food Canada
Rm. 1015, K.W. Neatby Bldg.
960 Carling Avenue
Ottawa, ON
K1A OC6

Dr. Rob Bourchier
Research Scientist
Insect Biology and Bio-control
Agriculture and Agri-Food Canada
Lethbridge Research Centre
P.O. Box 3000
Lethbridge, AB
T1J 4B1

Stéphan Brière
Diagnostic Plant Pathologist
Centre for Plant Quarantine Pests
Ottawa Laboratory Fallowfield
Canadian Food Inspection Agency
3851 Fallowfield Road
Ottawa, ON
K2H 8P9

Dr. Solke De Boer
Section Head and Research Scientist
Charlottetown Laboratory
Canadian Food Inspection Agency
93 Mt. Edward Road
Charlottetown, PE
C1A 5T1

Dr. Rosemarie De Clerck-Floate
Research Scientist and
Project User Representative
Agriculture and Agri-Food Canada
Lethbridge Research Centre
P.O. Box 3000
Lethbridge, AB
T1J 4B1

Gary Kristjansson
Coordinator and Editor
Biohazard Containment & Safety Unit,
Science Strategies Directorate,
Canadian Food Inspection Agency
159 Cleopatra Dr
Ottawa ON
K1A 0Y9

Paul Langevin
P.Eng
Biocontainment Design Services/Merrick
133 Paddock Way
Kanata, ON
K2L 1K6

Dr. John McDonald
Research Scientist
Centre for Plant Quarantine Pests
Ottawa Laboratory Fallowfield
Canadian Food Inspection Agency
3851 Fallowfield Road
Ottawa, ON
K2H 8P9

Stephen Miller
Plant Pathologist
Plant Health Risk Assessment Unit,
Science Strategies Directorate,
Canadian Food Inspection Agency
3851 Fallowfield Road
Ottawa, ON
K2H 8P9

Sylvia Miller
Nematologist
Centre for Plant Quarantine Pests,
Ottawa Laboratory Fallowfield
Canadian Food Inspection Agency
3851 Fallowfield Road
Ottawa, ON
K2H 8P9

Stephen Norman
A/National Manager
Biohazard Containment & Safety Unit,
Science Strategies Directorate,
Canadian Food Inspection Agency
159 Cleopatra Dr
Ottawa ON
K1A 0Y9

Doug Parker
Regulatory Entomologist
Centre for Plant Quarantine Pests,
Canadian Food Inspection Agency
K.W.Neatby Building, Floor 4
960 Carling Ave.
Ottawa, ON
K1A 0C6

Dr. Khalid Rashid
Research Scientist
Agriculture and Agri-Food Canada
Morden Research Station
Unit 100 - 101 Route 100
Morden, MB
R6M 1Y5

Dan Thompson
Plant Pathologist
Centre for Plant Health
Sidney Laboratory
Canadian Food Inspection Agency
8801 East Saanich Road
Sidney, BC
V8L 1H3

Dr. Alan Watson
Professor and Director
Biopesticides Research Laboratory
Macdonald College
2 Raymond Building, Room R2-019
21111 Lakeshore Road
Ste. Anne de Bellevue, QC
H9X 3V9

Bill Weiler
Legislation Officer,
Export/Import Section,
Plant Health Directorate
Canadian Food Inspection Agency
59 Camelot Drive, CFIA
Ottawa, ON
K1A 0Y9

Lisa Young
A/National Manager
Biohazard Containment & Safety Unit,
Science Strategies Directorate,
Canadian Food Inspection Agency
159 Cleopatra Dr
Ottawa ON
K1A 0Y9

TABLE OF CONTENTS

1. Introduction

1.1 Scope

This document describes the minimum acceptable physical and operational requirements for **facilities**[1] working with **plant pests**[2] other than weeds, soil[3], genetically modified plants, and arthropod **biological control**[4] agents.

Some of the information presented in these standards may be useful for the **containment** of biocontrol arthropods. However, the North American Plant Protection Organization's Regional Standard for Phytosanitary Measures (RSPM) No. 22: *"Guidelines for the Construction and Operation of a Containment Facility for Insects and Mites used as **Biological Control Agents**"* takes precedence over this document for the containment of biological control arthropods.

This document is intended to be used as a resource by Canadian Food Inspection Agency (CFIA) staff, and other persons who grow, raise, culture, or produce any thing that is a pest or is infected/infested with a pest. It provides guidance on the operation of plant pest containment facilities such as laboratories, **greenhouses** and **screenhouses**. Compliance with these standards and documents such as Import Permits will help to ensure that economically and environmentally significant plant pests do not inadvertently escape into the environment and become established in Canada.

1.2 Background

The *Containment Standards for Veterinary Facilities*, published in 1996 by Agriculture and Agri-Food Canada, provides guidance for those who design, build, operate or work in laboratories in which animal pathogens are handled. The *Laboratory Biosafety Guidelines, 3rd Edition*, published in 2004 by Health Canada, provides similar guidance for those involved with laboratories in which human pathogens are handled but neither of those two documents are intended to address the containment of plant pests.

Plant pests almost never infect or infest healthy people, and they therefore pose little direct risk to laboratory personnel. Some can, however, pose a significant threat to agricultural production, forests and natural environments. As a result, it is important that personnel working with plant pests or the facilities housing these organisms take steps to prevent the accidental escape of potentially damaging pests into the environment. The level of containment required to prevent escapes will depend on specific pest biology and the impact that an escape might have on the Canadian environment.

---

[1] See the Glossary for the definition of the bolded terms in the text.

[2] Any thing that is injurious or potentially injurious, whether directly or indirectly, to plants or to products or by-products of plants, and includes any plant prescribed as a pest [PPA 1990]. This includes any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products (IPPC, 2002) including, but not limited to, arthropods, molluscs, bacteria, fungi, nematodes, phytoplasmas, viruses, and viroids.

[3] Soil is regulated under Directive D95-26: "Phytosanitary requirements for soil and related matter, alone or in association with plants" (http://www.inspection.gc.ca/english/plaveg/protect/dir/d-95-26e.shtml).

[4] Refer to NAPPO (2004) and DeClerk-Floate (2006) for the importation and release process for biological control arthropods and for containment facility requirements, respectively.

Most countries, including Canada, have developed regulations to prevent the introduction and spread of economically and environmentally significant plant pests. Canada's *Plant Protection Act* serves to protect plant life and the agricultural and forestry sectors of the Canadian economy by preventing the importation, exportation and spread of pests, and by controlling or eradicating pests in Canada. The *Plant Protection Act* and *Regulations* give the CFIA the authority to prohibit or restrict the movement into, within, and out of Canada[5] of any plant pest or other thing that is or could be infested with a pest, or is or could be a biological obstacle to the control of a plant pest. The Act also provides other authorities such as inspection powers.

Researchers frequently undertake studies on the biology, ecology, detection, identification, control and eradication of plant pests. Additionally, scientists often study exotic, beneficial organisms to determine if they have potential as biological control agents. Persons wishing to import plant pests or potential biological control agents must apply to the CFIA for a Permit to Import[6]. For first-time introductions of foreign biological control agents, a full petition following the standards of the North American Plant Protection Organization[7] (NAPPO) must be submitted to the CFIA, requesting authority to import and release the agent into the environment. The petition must contain detailed information on the agent's biology and ecology obtained through careful scientific survey and/or experimentation. Risks associated with each importation are assessed by regulatory scientists who determine if the importation should be allowed, prohibited or restricted. Where importation is restricted, the CFIA will stipulate import conditions to mitigate pest risks, and site visits may be conducted by CFIA Inspectors to verify that the proposed facilities and operational procedures are adequate to contain imported pests.

---

[5] Certain plant pathogens that could be used to develop biological weapons appear on the Export Control List and are regulated by the Department of Foreign Affairs and International Trade (DFAIT) see http://www.dfait-maeci.gc.ca/trade/eicb/military/gr7-en.asp?#group7

[6] See http://www.inspection.gc.ca/english/for/pdf/c5256e.pdf for instructions for Permits to import.

[7] For a full explanation of this process see De Clerck-Floate, R.A., P.G. Mason, D.J. Parker, D.R.Gillespie, A.B. Broadbent and G. Boivin. 2006. Guide for the importation and release of arthropod biological control agents in Canada. AAFC publication, Ottawa. In Press.

2. Plant Pest Containment

2.1 Pest Biology and Containment

In order for a plant pest to survive, establish and spread in an environment, the following conditions are needed: 1) the pest must be able to find a suitable host; 2) susceptible material (e.g. plant tissue) must be available; and 3) the environment must be conducive for the establishment and development of the pest. These three factors must all occur over a sufficient and overlapping period of time. Natural limitations to any one of the three factors and/or human intervention, such as the use of chemical or biological controls can influence pest establishment or spread. Thus, plant pests can be contained by spatial and temporal isolation from their hosts, either in the natural environment or in **containment facilities**.

In order to prevent the escape and establishment of plant pests into the environment, facilities and their operating procedures must be appropriate to the biology of the specific pests under consideration. In addition, operating procedures must prevent the introduction of organisms into the facility that could contaminate, kill or transmit contained pests. Singh (1999) states that, "Containment requirements for various pathogen [and other pest] groups will vary according to the pest risks they pose to … agriculture because of their unique biologies, particularly their modes of dispersal, and their survival potential under adverse conditions". Organisms such as bacteria, viruses, phytoplasmas and nematodes, in the absence of arthropod vectors, do not generally have any capability of being dispersed long distances. Arthropods can actively disperse or be passively dispersed by air currents, but their spread can be mitigated by sealing facilities and by using appropriately sized filters or screening. Fungi that are not well adapted to aerial dissemination can also be contained relatively easily, but those fungi that produce spores adapted for efficient aerial dissemination are very difficult to contain and may require the use of sealed facilities with **HEPA filtered** ventilation systems. Containment precautions must also be appropriate to the proposed type of work. Containing pests *in vitro* (e.g. as pure cultures on petri plates) is inherently easier than containing pests *in vivo* (e.g. on infected or infested plants) and, similarly, containing pests in small-scale experiments presents a lower risk of pest escape than containing them in large-scale experiments.

Effective containment involves trained personnel, appropriate and documented operational procedures, effective use of **primary containment** devices, and facilities designed to limit access to authorized personnel.

2.2 Risk Assessment, Risk Management and Containment

Facilities handling plant pests should be constructed and operated to containment levels appropriate to the pest being contained. The level needed depends upon the risk of the plant pest escaping and establishing in the environment and on the environmental, economic, agricultural, forestry and trade impacts of such an introduction.

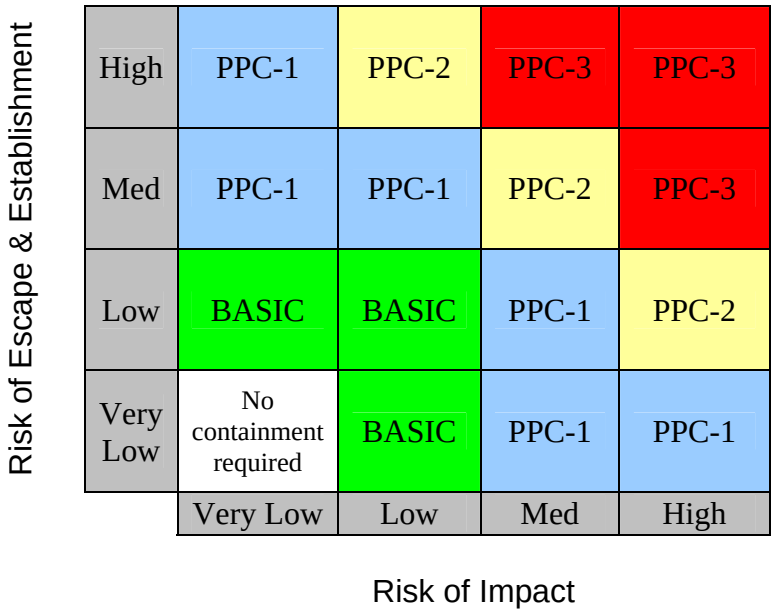
To provide a framework for ensuring biological containment when working with plant pests in Canada a containment classification system has been developed that is consistent with those for human and animal pathogens. It has four containment levels: Basic; Plant Pest Containment level 1 (PPC-1); Plant Pest Containment level 2 (PPC-2); and Plant Pest Containment level 3 (PPC-3). Physical and operational requirements for these levels are described below (section 2.3) and comprehensive and detailed descriptions for PPC-1, PPC-2 and PPC-3 are found in sections 3 (Physical Requirements) and 4 (Operational Practices) of this document. The containment requirements for a particular organism are frequently project-specific, and are determined after assessing pest risk factors such as:

- the known presence or absence of the organism in Canada;
- its host range and the local presence of potential hosts;
- the existence of, or the potential for, significant organism biotypes or strains that are exotic to an area;
- the history of the organism in other new environments;
- the virulence or aggressiveness of the organism;
- the availability of pest risk information;
- the nature of the proposed work (*in vitro*, *in vivo* or large-scale *in vivo*);
- the location, proximity of suitable hosts and time of year of the proposed work;
- the mode of transmission or spread (e.g. active flight, passive air-borne, contact, soil-borne, water-borne);
- its potential rate of local and long-distance spread;
- the presence of vectors in Canada (e.g. arthropods, fungi, nematodes);
- the presence of vectors in or near the containment facility;
- the persistence of the organism in the environment and its potential for overwintering;
- environmental requirements for establishment and spread;
- the potential capacity to control or eradicate the organism if it escapes;
- the potential for economic or environmental loss from the organism;
- the economic and environmental significance of potential pest organisms and their host plants; and
- biosecurity-related risks (e.g. the potential for theft and misuse).

Based on a review of the above, regulatory scientists make risk management recommendations to reduce the risk of organism escape and establishment in Canada. Appropriate containment levels are determined by a reviewer who considers the conceptual risk model (Figure 1) below. The risk model demonstrates the general principle of requiring increased levels of containment with increasing risk of pest escape and establishment and increasing economic, environmental, agricultural, forestry and trade impacts associated with an escape. There are many methods of assessing risk.

Figure 1 is a simplified graphical representation of how risk can be quantified for plant pests.

Figure 1. Conceptual Risk Model for Determining Containment Level



2.3 Plant Pest Containment Levels

Regardless of the containment level of the facility, the physical attributes of the facility and operational procedures must be adequate for the purpose of containing the pest(s) under consideration and should be tailored to that purpose. Due to the variables involved, the appropriate containment of plant pests must be considered on a case-by-case basis and specific applications may require precautions additional to those described for each of the containment levels.

The concept of biological containment is usually applied to work done in buildings, **growth chambers** or greenhouses which have, or present, physical barriers to prevent the escape of pests. Although the concept of biocontainment under field conditions seems contradictory, there are some pests that can safely be contained under quarantine conditions in the field. For example, areas with natural geographic isolation (e.g. islands), a local absence of susceptible host tissue, or a climate unsuitable for long term pest survival may be effective in preventing the escape and establishment of particular plant pests.

Comprehensive descriptions of each containment level are provided in sections 3 (Physical Requirements) and 4 (Operational Practices). Simplified facility diagrams for PPC-1, PPC-2 and PPC-3 are presented in Appendix 1. The following brief descriptions explain the major features of each containment level and provide illustrative examples of the type of plant pest work that would be appropriate at each level.

2.3.1 BASIC

Basic containment is the lowest containment level for plant pests and it provides simple, but adequate, barriers to pest escape. Facilities may consist of field plots, basic laboratories or simple glass, plastic or screenhouses that may have dirt or gravel floors, and unscreened vents. Containment of plant pests is achieved through sanitation (see 4.1.5.16), spatial isolation from susceptible hosts, physical security, signage, destruction of waste and destruction of all viable pests at the end of the experiment or testing period. Basic containment is applicable for work with low to very low risk plant pests for scientific, research, educational, processing, industrial or exhibition purposes.

The following are brief examples of the types of work that would be appropriately conducted (with or without supplemental conditions) in Basic containment:

- establishing a field plot with plants infected with a virus that can only be transmitted by grafting;
- using lyophilized virus-infected plant tissue as a control in an ELISA test; or
- using plant tissue infected with a common strain of tobacco mosaic virus to inoculate tobacco plants for a high-school biology project.

2.3.2 Plant Pest Containment Level 1 (PPC-1)

PPC-1 containment is the next highest containment level for plant pests. Facilities include permanent structures such as laboratories, greenhouses and screenhouses. Windows that can be opened must be fitted with appropriate screens and greenhouses must be fully screened and caulked to both contain and exclude arthropods. An autoclave must be available to treat waste and waste water must be treated to kill pests where appropriate. Containment is achieved primarily through operational practices including training in safety and containment precautions, limiting access to authorized personnel, use of protective clothing, effective sanitation and housekeeping, monitoring for and controlling undesired pests, and the use of good laboratory practices.

The following are brief examples of the types of work that would be appropriately conducted (with or without supplemental conditions) in PPC-1 containment:

- inoculating host plants with isolates of plum pox or other plant viruses in the absence of their vectors;
- importing low-risk tropical insects into butterfly houses for study, display or rearing; or
- studying and rearing nematodes of quarantine concern to Canada that have low spread potential (e.g. *Globodera rostochiensis* and *Ditylenchus destructor*).

2.3.3 Plant Pest Containment Level 2 (PPC-2)

PPC-2 facilities include permanent structures such as laboratories and greenhouses but not screenhouses. Containment is achieved through facility design, operational procedures and the use of specialized equipment. All PPC-1 physical and operational requirements also apply to this containment level.

Key additional operational practices include:

- use of primary containment devices;
- use of dedicated or disposable laboratory clothing;
- appropriate decontamination of solid and liquid waste;
- pest monitoring and regular inspection of screens, filters and caulking for defects;
- clear documentation of **standard operating procedures (SOPs)**;
- mandatory personnel training; and
- the availability of suitable emergency response plans.

Key additional physical requirements include:

- restricted access via an anteroom;
- an on-site autoclave; and
- greenhouses that are mechanically ventilated with screened or filtered inlet and exhaust air.

Key additional physical requirements for PPC-2 arthropod facilities include:

- sealing or screening all penetrations into the work area;
- **inward directional airflow**; and
- access via a dedicated anteroom.

The following are brief examples of the types of work that would be appropriately conducted (with or without supplemental conditions) in PPC-2 containment:

- conducting plant inoculations with an isolate of *Ralstonia solanacearum* Biovar 2, Race 3, the causal agent of potato brown rot disease;
- morphological examination and DNA extraction of sporangia of *Synchytrium endobioticum*, the causal agent of Potato Wart, and their use as diagnostic controls;
- growing chrysanthemum plants infected with *Puccinia horiana*, the cause of chrysanthemum white rust;
- rearing the arthropod pest *Anoplophora glabripennis*, the Asian long horned beetle;
- conducting plant inoculations with specific races of the corn pathogen *Helminthosporium turcicu*;
- conducting fruit inoculations in a laboratory with *Alternaria gaisen*, the causal agent of Black Spot of pear; or
- culture work with, and diagnostics for, *Phytophthora ramorum*, the causal agent of Sudden Oak Death.

2.3.4 Plant Pest Containment Level 3 (PPC-3)

PPC-3 is the highest containment level for plant pests. All PPC-1 and PPC-2 physical and operational requirements apply to this containment level. Containment is achieved through highly specialized facilities, stringent operational procedures and the use of specialized equipment. Designing, constructing and maintaining a PPC-3 greenhouse facility is complex and expensive. The use of growth chambers or **growth rooms** within a PPC-3 facility can be a cost-effective alternative to constructing a PPC-3 greenhouse.

Key additional operational practices include:

- designation of a person with responsibility for the overall operation of the facility;
- a high level of physical security;
- restricted access with a log being kept of personnel and visitors entering the facility;
- full clothing change before entry with potential for washing or showering on exit if required;
- checks to confirm inward directional airflow and regular inspections for deterioration in sealing; and
- a procedural manual, including standard operating procedures (SOPs) that address all emergencies including those relating to containment.

Key additional physical requirements include:

- dedicated anterooms with change areas;
- sealed facilities with inward directional airflow from "clean" to "dirty" areas;
- HEPA filtered exhaust air;
- drains routed to an effluent treatment system;
- electronic data transfer capability;
- emergency power for critical containment systems; and
- break-resistant glazing for greenhouses.

The following are brief examples of the types of work that would be appropriately conducted (with or without supplemental conditions) in PPC-3 containment:

- conducting plant inoculations with isolates of *Phakopsora pachyrhizi*, the causal agent of Asian Soybean Rust, in an area in close proximity to susceptible hosts;
- conducting plant inoculations with imported isolates of *Gymnosporangium yamadae*, the causal agent of Japanese Apple Rust, in an area in close proximity to susceptible hosts;
- biocontrol research with exotic microbial plant pests that are difficult to contain and where the establishment risks are poorly documented; or
- conducting plant inoculations with pests of environmental and/or economic concern that have a high establishment and/or trade potential and that produce airborne spores, such as with the pathogen *Phytophthora ramorum*.

3. Physical Requirements for Containment Facilities

This chapter describes physical requirements for the containment of plant pests. The facility must be adequate to contain all pest organisms in use and it must be appropriate to contain the pest requiring the highest level of containment. New facilities must be constructed to meet applicable construction standards.

3.1 Primary Containment

Primary containment devices (e.g. **biological safety cabinets**[8] **(BSCs)**, insect cages etc.) and the use of good laboratory technique reduce the overall pest pressure inside the **containment perimeter**. Primary containment, therefore, reduces reliance on the **secondary containment** provided by the design of the facility.

Biological safety cabinets provide personnel, product and environmental protection from airborne or aerosolized microorganisms. BSCs of class II, Type A1, A2, B1 and B2 are appropriate for work with plant pathogens. The exhaust air from these cabinets is HEPA filtered thus providing an extra level of protection against pest escape. Similarly, insect cages provide increased levels of containment by preventing the unrestricted movement of arthropods or by excluding potential arthropod vectors. Growth chambers and growth rooms can offer a cost-effective alternative to containment greenhouses while providing more precise levels of environmental control. Growth chambers and growth rooms can be located within a **containment zone** and thus provide primary containment or they can be sealed and modified to meet PPC-2 or PPC-3 containment requirements.

3.2 Secondary Containment

Facility design and construction provides effective secondary containment to prevent the release of plant pests that have escaped from primary containment. Selection, design and installation of doors, windows, screening, and air handling systems along with the use of appropriate sealants will determine how well a facility can contain plant pests. Facility design and construction must be complemented with dedicated and trained staff that follow documented procedures and effectively utilize primary containment measures wherever feasible to minimize pest escape.

3.3 Risk Mitigation

Risk mitigation measures should be applied within containment facilities, where feasible, to reduce the risk of pest escape and thereby effectively reduce the physical containment requirements needed for a particular plant pest. These measures may include providing adequate isolation between infected and uninfected hosts, providing a vector-free environment, caging insects and plants, and rendering all material non-viable at the end of experiments. Risks from plant pests can also be mitigated by locating containment facilities in areas where susceptible hosts are not present, and by conducting work at times of the year when local hosts are not present or where, or when, local weather

[8] Refer to chapter 9 of the Laboratory Biosafety Guidelines (http://www.phac-aspc.gc.ca/publicat/lbg-ldmbl-04/index.html) for a detailed description of BSCs and their installation, certification and use.

conditions would kill escaping pests.

3.4 Design Considerations for New Facilities

Facility design needs to address pest-specific issues in order to enhance the overall performance and operation of a containment laboratory, greenhouse or screenhouse. Designers, owners and operators should consider:

- Facility location - The site chosen for a containment facility should include an assessment of local agricultural and forestry programs as well as the local environment. A containment facility can be safely constructed in almost any location depending on available resources and construction methodologies. The risk to agriculture, forestry and the environment including the impact of possible pest releases, should be considered before beginning work with a particular pest. In areas prone to natural disasters, buildings and support systems should meet enhanced building code measures for construction of containment facilities.

- Energy conservation - If energy conservation is considered (e.g. through the use of building automation controls, night air-change set-back (reductions), heat recovery and air recirculation) these measures must not compromise the containment provided by the facility.

- Inward directional airflow - Several standards (e.g. ANSI/AIHA Z-9.5-1992 and NFPA 45) recommend or require the use of inward directional airflow (IDA) for new laboratory construction. Although it is advisable for new and existing facilities to have IDA, this is only a requirement for PPC-2 arthropod facilities and all PPC-3 facilities.

- Sealed PPC-3 containment zones should be located away from exterior walls to avoid pressure reversals due to high winds. This can not be done with greenhouses but their construction must be designed to prevent unplanned air infiltration.

- New facilities require storage space for supporting operations, cleaning, spill management, emergency safety response programs, tools and equipment. Dedicated equipment, washroom facilities, storage areas and clerical workstations inside the containment zone should be considered to minimize traffic into and out of the containment facility.

- Containment facilities require frequent wash-down of surfaces and need to have these surfaces designed with a resistance to chemical attack and absorption. The underside of plastic laminated benches may contain absorptive organic materials that must be sealed in PPC-3 facilities to facilitate cleaning and to prevent absorption of fumigants. Use of epoxy bench-top surfaces, stainless steel, or other non-absorptive solid surfaces is preferred.

- To facilitate decontamination and maintenance, systems such as liquid effluent treatment systems and HEPA filter housing systems must be located as close as

possible to the containment perimeter and consideration should be given to the installation of valves to isolate sections of ductwork and drains. Appropriately sized screens or filters need to protect all openings that may be routes for incoming or escaping arthropods.

- Circuit breakers and shut off valves should be located outside of the containment perimeter to facilitate maintenance.

3.5 Greenhouse Design Considerations

All requirements for ventilating and controlling containment laboratories need to be considered when designing ventilation requirements for greenhouses. Typically, greenhouses have high humidity, high heat production, significant cold weather influences and increased chances of ingress or egress by flying vectors. Ventilation strategies need to include screening of all forced air and natural air venting systems. Air conditioning may include a combination of cooling/heating (temperature control), humidity control, CO_2 control and air circulation patterns. In greenhouses that rely on screened natural air venting it will be difficult to maintain negative pressure in areas prone to high winds. Greenhouses that are designed to be tight without opening vents require verification of their as-constructed performance and regular testing for leaks.

A control system that integrates lights, ventilation requirements, temperature control and shading systems should be considered when constructing a containment greenhouse.

Where it is necessary to collect and treat waste water, greenhouse floors should be sloped toward drains and have curbs to contain water.

To increase physical security, consideration should be given to locating greenhouses away from public walkways and other amenities. Consideration should also be given to the use of **kneewalls**, windbreaks and physical barriers to reduce the probability of loss of containment due to mechanical damage to the greenhouse by things such as machinery and carts.

3.6 Screenhouses

Screenhouses may be constructed to provide BASIC or PPC-1 containment.

3.7 Physical Containment Requirements

The following tables describe physical containment requirements for facilities (e.g. laboratories, greenhouses, screenhouses) working with plant pests. The following symbols are used:

- ● **Required**
- ❍ **Recommended**[9]

The absence of a symbol in the tables indicates that an item is either not required or not applicable. Where ● or ❍ are followed by an "A" suffix that item applies only to arthropod facilities. Where the "A" suffix does not appear the item applies to all facilities, including those working with arthropods.

3.7.1 Structure, Location and Access

3.7.1	Structure, Location & Access:	PPC-1	PPC-2	PPC-3
1	Adequate security to be provided for the building (e.g. fencing, motion sensors, physical barriers, patrols).		❍	●
2	Signage to be installed on entry doors within the containment zone indicating containment level, contact information, and entry requirements.	❍	●	●
3	Entry to the containment zone to be by self-closing and lockable doors.	❍	●	●
4	Restricted access to the containment zone is to be provided by a controlled access system (e.g. electronic access card, code or equivalent).	❍	●	●
5	Entry and exit to be via an anteroom. Where stipulated by building codes anterooms that permit rapid emergency egress are to be placed at emergency exits. Corridors are acceptable as anterooms for non-arthropod PPC-2 areas.		●	●
6	If separate from a containment facility greenhouse and screenhouse entry and exit to be via an anteroom. Corridors and **headerhouses** are acceptable for PPC-1 and PPC-2 facilities.	❍	●	●

[9] Recommended items are optional, depending upon the nature of the pest(s) requiring containment.

3.7.1	Structure, Location & Access:	PPC-1	PPC-2	PPC-3
7	Anteroom doors to be self closing and are not to open simultaneously (interlocking doors, and audible or visual alarms are acceptable).		●	●
8	Anteroom to be provided with windowless self-closing doors and lights that automatically switch off when either door is opened, and switch on only when both doors are closed, to avoid attracting phototropic arthropods.		● A	● A
9	Entry to allow for separation of personal clothing from dedicated facility clothing (i.e. "clean" change area separated from "dirty" change area).		● A	●
10	Anterooms can be considered as a change room and a single change room can include both a clean and dirty change area with a line demarcating the difference.		● A	●
11	Insect traps (e.g. sticky, pheromone, visible or ultraviolet light) to be provided in the anteroom of the containment zone.	❍ A	● A	● A
12	Tight-fitting doors (e.g. with weather striping, magnetic seals, brush barriers or flexible flanges) and, preferably, a raised threshold to be provided to deter ingress or egress by arthropods.		● A	● A
13	The inner anteroom door to be fitted with a forced air curtain, as required, to deter arthropods from exiting the containment zone.		❍ A	❍ A
14	Mirrors to be installed within the containment zone and immediately inside of anteroom for self-inspection for hitchhiking arthropods.		● A	● A
15	Emergency exits to be provided, where required, that open only from the inside, are alarmed and display “Emergency Exit Only” signage to deter unauthorized access.	❍	●	●

3.7.1	Structure, Location & Access:	PPC-1	PPC-2	PPC-3
16	Dedicated laboratory clothing and personal protective equipment (PPE) is to be stored separately from street clothing.	❍	●	●
17	Lowered ceilings to be provided in arthropod rearing rooms to facilitate arthropod recapture.		❍ A	❍ A
18	Facilities, including greenhouses and screenhouses, are to be designed to withstand extremes of local weather and anticipated maximum snow and ice loads, as well as wind, windborne debris and hail.	❍	●	●
19	Greenhouses to be constructed with a rigid reinforced frame with walls, floors, and glazing forming a shell. All perforations and joints in greenhouses and between the greenhouse and other contained structures to be sealed to provide a continuous containment barrier.		●	●

3.7.2 Surface Finishes and Casework

Surface finishes should be scratch and stain resistant, easy to clean and durable enough to withstand repeated disinfection, while offering minimal opportunity for pests to persist and cross-contaminate samples. Appropriate surface colouration is important for facilities working with arthropods, to facilitate the detection of escaped individuals.

3.7.2	Surface Finishes and Casework:	PPC-1	PPC-2	PPC-3
1	Surfaces to be continuous and compatible with adjacent and overlapping materials (to maintain adhesion and a continuous perimeter). For PPC-3 containment, walls and floors with welded seams are acceptable. A continuous 100mm (minimum) cove floor finish up the wall is recommended.		● A	●
2	Floors to be slip-resistant in wet areas.		●	●
3	Interior coatings to be easy to clean, resistant to gas, chemicals, and repeated disinfection in accordance with function (e.g. will withstand disinfection, fumigation).		●	●
4	Bench tops to be non-absorptive, impervious to water, and resistant to acids, alkalis, organic solvents and moderate heat. Backsplashes to be installed tight to wall and sealed at wall-bench junction.	❍	❍	●
5	Greenhouse floors to be impervious to water and easy to clean (e.g. concrete).	❍	●	●

3.7.3 Heating, Ventilation and Air Conditioning (HVAC)

Systems must be capable of providing a comfortable environment for laboratory staff that is also suitable for the organisms with which they work.

3.7.3	Heating, Ventilation and Air Conditioning:	PPC-1	PPC-2	PPC-3
1	Inward directional airflow to be provided such that air will always flow towards areas of higher containment (e.g. ± 12.5 - 25 Pa differential).		● A	●
2	Supply and exhaust air to be appropriately filtered or screened to contain and exclude pests.		● A	
3	Supply and exhaust air systems are to be designed to prevent backdraft of contaminated air to other areas.		● A	
4	Supply and exhaust air ducts to be equipped with dampers to allow for screen or filter cleaning, removal, and replacement.		● A	
5	Supply and exhaust air ducts to be equipped with bubble-tight dampers to permit gaseous or fumigant decontamination (the bubble-tight dampers can also be used to provide backdraft protection and isolation of the HEPA filters).			●
6	Exhaust air to be HEPA filtered. HEPA filters to be installed in a certifiable housing.			●
7	Bubble-tight dampers should be installed as close as possible to the containment perimeter.			❍
8	Pre-filters or screens should be installed to protect, and extend the life of, the HEPA filters.			❍
9	Filter housings and ductwork to be able to withstand pressure changes due to air supply and/or exhaust fan failures.			●
10	HVAC filter efficiency is to be demonstrable with the filter in place.			●

3.7.3	Heating, Ventilation and Air Conditioning:	PPC-1	PPC-2	PPC-3
11	Airflow control devices and duct sensors to be located downstream of the exhaust HEPA filter and upstream of the supply bubble tight damper or HEPA filter.			●
12	Supply and exhaust air systems to be interlocked to prevent sustained laboratory positive pressurization.		● A	●
13	Supply and exhaust air ductwork to be sealed airtight between the room perimeter and HEPA filter or bubble tight damper(s) in accordance with SMACNA Seal Class A 1985.		❍ A	●
14	Alarms (audible or visible) to be provided both inside and outside the containment zone to signal air handling systems failure.		❍ A	●
15	Visual pressure-monitoring devices to be provided at the entry to the containment zone.		❍ A	●
16	Greenhouse vents and greenhouse HVAC penetrations to be screened with appropriate mesh screening to prevent pest escape.	●	●	
17	Greenhouses constructed to meet PPC-3 level must undergo and pass the following tests: (a) an air infiltration test conducted according to ASTM E 283-91: the test pressure difference will be 6.24 pounds per square foot positive static pressure, and the allowable leakage rate is 0.03 cfm per square foot; (b) a static pressure water resistance test conducted according to ASTM E 331-93: the minimum test pressure will be 10 pounds per square foot, and the passing standard is no water penetration to the interior surface; and (c) a dynamic pressure water resistance test conducted according to AAMA 501.1-94: the minimum test pressure will be 10 pounds per square foot, and the passing standard is no water penetration to the interior surface.			●
18	Greenhouse ventilation system to be designed to allow for greenhouse fumigation and pesticide applications.	●	●	●

3.7.4 Containment Perimeter

The containment perimeter is the continuous floor, ceiling and wall surfaces that form a barrier against the ingress or egress of plant pests, including all windows, doors and service penetrations into the area.

3.7.4	Containment Perimeter:	PPC-1	PPC-2	PPC-3
1	Autoclave or other **validated** and acceptable means of waste treatment/disposal to be located within the containment zone or, if not available in the containment zone, then procedures must be in place to safely transport waste for treatment/disposal elsewhere.	●	●	
2	Dedicated double-door barrier autoclave with bio-seal flange to be located on the containment barrier; equipped with interlocking doors (recommended) or audible or visual alarms, to prevent or deter the simultaneous opening of both doors. Body of the autoclave should be located outside containment for ease of maintenance.			●
3	Autoclave to be equipped with a cycle log recorder to record time, temperature, and pressure.	❍	●	●
4	For materials that require removal from the containment zone and cannot be autoclaved (e.g. heat sensitive equipment, samples, film) other proven and validated treatment technologies (e.g. irradiation, chemicals, gas) are to be provided at the containment barrier.			●
5	All penetrations of the containment perimeter, including all conduits and wiring, to be sealed with an appropriate sealant to facilitate cleaning, fumigation and to prevent arthropod escape.		● A	●
6	Windows positioned on containment barrier to be non-opening and sealed appropriate to local climactic conditions; window glazing material must provide the required level of security.		● A	●

3.7.4	Containment Perimeter:	PPC-1	PPC-2	PPC-3
7	Containment zone to be screened or sealed for PPC-1 and PPC-2, and sealed for PPC-3 and PPC-2 arthropod containment zones.	●	●	●
8	Spare greenhouse window panels, emergency glazing and screening to be stored nearby for emergency repairs.	❍	●	●
9	Greenhouse glazing must be break resistant (e.g. double glazing, laminated or tempered glass, polycarbonate) and provide the required level of security.		● A	●
10	Greenhouse glazing must be sealed to the greenhouse framework with a sealant that provides a tight, flexible and continuous seal resistant to degradation by chemical disinfectants, UV radiation and temperature changes.		●	●

3.7.5 Facility Services

Facility services include all plumbing, electrical, gas, oil and safety equipment, etc. related to the operation of the facility. All such systems must be installed in a manner that does not compromise the containment required for the plant pests that will be used in the facility.

3.7.5	Facility Services:	PPC-1	PPC-2	PPC-3
1	A handwashing sink (or, if required, a sink and a shower) to be located within the containment zone and near the point of exit.	❍	●	●
2	Handwashing sinks to be provided with "hands-free" capability.		❍	●
3	Appropriate primary containment devices to be available (e.g. BSCs), as required, to minimize the potential contamination of the containment zone.	❍	●	●
4	Emergency eyewash facilities to be provided in the laboratory containment zone in accordance with activities and applicable regulations (i.e. ANSI Z358.1-1998).	●	●	●
5	Emergency shower equipment to be provided in the laboratory containment zone in accordance with activities and applicable regulations (i.e. ANSI Z358.1-1998).	●	●	●
6	Facility service supply controls to be located both inside and outside of the containment zone, as required, to facilitate servicing.		❍	❍
7	All drains and associated piping to be connected to a validated effluent sterilization system consistent with laboratory activity and local regulations.			●
8	150 mm drain traps to be provided to avoid trap drying.		● A	●
9	Soil traps to be installed in drains as required.	●	●	●
10	Plumbing vent lines (including effluent sterilization system) to be appropriately screened or filtered to prevent ingress and egress of arthropods.		● A	● A

3.7.5	Facility Services:	PPC-1	PPC-2	PPC-3
11	Communication system (e.g. fax, LAN, modem) to be provided to allow the electronic transfer of information and data from the containment zone to other areas.		❍ A	●
12	Intercom or telephone system to be provided to allow voice communication beyond the containment zone and to reduce traffic into and out of containment zones.		❍ A	●
13	Laboratory to be adequately equipped (e.g. BSCs, thermocyclers, ELISA plate readers, centrifuges and microscopes) to avoid moving equipment into or out of the containment zone.		❍	●
14	Alarm system to be installed to detect loss of containment due to unauthorized entry or mechanical or power failure.		❍	●
15	Monitoring and security system to be installed to monitor critical containment systems. System monitoring to be available outside of the containment zone.		❍	●
16	Emergency power system to be provided for HVAC, lighting, BSCs, essential equipment, and other safety systems.		❍	●
17	Vacuum pump contamination to be minimized by filtration of vacuum line and use of disinfectant traps.		❍	●

4. Operational Practices in Containment Facilities

This section describes containment practices applicable to plant pests. Operational practices must be adequate to contain all organisms in use. Facility personnel, including scientists, technicians, and maintenance and greenhouse staff, all play an essential role in the successful containment of plant pests and the exclusion of unwanted pests from containment facilities.

4.1 PPC-1 Practices

The following general practices are required when working with plant pests in a PPC-1 facility.

4.1.1 Access

Limit access to containment zone and support areas to authorized personnel only.

4.1.2 Documentation

4.1.2.1 Designate and name a contact person for the facility, or one for each area or experiment.

4.1.2.2 Keep an up-to-date inventory of all imported plant material and plant pests.

4.1.3 Training

Personnel must be trained in pest-associated hazards and the precautions necessary to prevent release of contained pests. Personnel must show evidence that they know and understand the required precautions, training must be documented, and refresher and retraining programs must be implemented as appropriate.

4.1.4 Personal Protective Equipment

4.1.4.1 Appropriate protective clothing, properly fastened, should be worn by all personnel, including visitors, trainees and others, when working in the facility to ensure that pests are not inadvertently transported outside of the containment facility on street clothing.

4.1.4.2 Potentially contaminated laboratory clothing must not be worn in non-laboratory/greenhouse/screenhouse areas if this presents a risk of inadvertently disseminating pests.

4.1.4.3 Gloves (e.g. latex, vinyl, co-polymer) can be worn, as appropriate, to avoid the inadvertent contamination of samples and work areas; gloves are to be removed when leaving the containment zone and **decontaminated,** as appropriate, with other laboratory wastes before disposal.

4.1.5 Work Practices

4.1.5.1 Comply with all conditions stipulated on Permits to Import.

4.1.5.2 Render all organisms non-viable prior to disposal.

4.1.5.3 Employ good laboratory practices to avoid the escape of pests.

4.1.5.4 Keep doors closed to reduce the potential movement of plant pests.

4.1.5.5 Eating, chewing gum, drinking, smoking, storing of food and utensils, storing of personal belongings, applying cosmetics, and inserting or removing contact lenses should not occur in the containment zone. The wearing of contact lenses is recommended only when other forms of corrective eyewear are not suitable.

4.1.5.6 Long hair is to be tied back or restrained so that it cannot come into contact with hands, specimens, containers or equipment where there is a possibility that this may disseminate pests.

4.1.5.7 Treat all pests and materials in a containment zone in accordance with the highest containment requirement for that area (e.g. if PPC-1 and PPC-2 pests are in the same room, PPC-2 practices must be followed).

4.1.5.8 Any pest, or material that is infested or suspected of being infested with a pest, must be moved or transported in containers that are secure, leak-proof, and are not easily broken to prevent the accidental release or escape of a pest. The containers must only be opened within a facility which meets the appropriate containment level for the pest in question.

4.1.5.9 Keep work areas within a containment zone, including dedicated clerical work stations, clean and tidy. Storage of materials should be minimized, and paperwork should be done outside of containment zones if this presents a risk of disseminating pests.

4.1.5.10 Keep workplace exposure to any plant pest to the lowest practical level and avoid the creation of unnecessary aerosols when manipulating pests or inoculating plants.

4.1.5.11 Cultures are to be stored in sealed, preferably break-resistant, containers such as screw-top vials. Cultures are to be clearly identified and dated. Where possible, petri dish cultures of sporulating fungi should be sealed with stretch film.

4.1.5.12 Contaminated materials and equipment must be appropriately cleaned and decontaminated before leaving the facility for servicing or disposal.

4.1.5.13 Render non-viable all unintentionally introduced pests, including those contaminating cultures, as soon as they are detected.

4.1.5.14 Where practical, confine all arthropods in cages or other containers that prevent escape.

4.1.5.15 Where applicable, disinfectants which are effective against the organisms in use must be available at all times where plant pests are handled or stored.

4.1.5.16 Sanitation practices should be followed when working with plants and plant pests. These practices include:

- treating all plants and soils as if they are infected/infested;
- minimizing entry of personnel into laboratory and plant growth areas;
- providing adequate separation and/or physical barriers between plants infected or infested with different plant pests;
- washing hands, after gloves have been removed, before leaving the containment zone, and at any time after handling materials known or suspected to be contaminated with plant pests if this poses a risk of inadvertently spreading pests;
- using decontaminated soil, soil-less potting mix or inert growing media, and cleaning up spilled soil or growing medium;
- watering plants carefully, avoiding soil and water splash, and touching plants with the hose;
- avoiding the use of automated watering systems where their use presents a risk of disseminating pests;
- cleaning and decontaminating work surfaces as appropriate with a suitable disinfectant;
- disinfecting items such as clippers, pruners and knives during and after use as appropriate to avoid plant-to-plant transfer of pests;
- cleaning and decontaminating pots, stakes and saucers after use, or using disposables that are decontaminated and discarded after use;
- surface sterilizing plant material before planting or initiating into tissue culture;
- maintaining obligate parasites (e.g. viruses, nematodes) in tissue culture plantlets where possible;
- eliminating unwanted pests by heat or cold therapy, surface sterilization, meristem culture or other suitable means;
- inspecting for, and removing and destroying, host plants infected or infested with unwanted organisms;
- using good housekeeping practices to keep the area neat, clean and

free of dead plant material and unwanted plants and pests; and
- using dedicated cleaning equipment (e.g. brooms, mops, garbage cans) within containment zones.

4.1.5.17 Work surfaces that have become permeable (i.e., cracked, chipped, or loose) must be repaired, sealed, or replaced.

4.1.5.18 Monitor autoclaves used for decontamination regularly using biological indicators to ensure efficacy (e.g. consider weekly or monthly monitoring, depending on the frequency of use of the autoclave). Monitoring records must be kept for three years.

4.1.5.19 Loss of containment must be reported immediately to the laboratory supervisor and remedied as soon as possible. Written reports of such incidents must be maintained for three years, and the results of incident investigations used for continuing education.

4.1.5.20 Maintain an effective bird, rodent, weed and plant pest control program to prevent entry and eliminate undesired pests from the containment zone.

4.1.5.21 Greenhouse personnel who apply pesticides must be appropriately trained and protected.

4.2 PPC-2 Practices

In addition to the practices required for PPC-1 facilities handling plant pests, the following sections describe the minimum operational practices required for PPC-2 containment facilities.

4.2.1 Access

4.2.1.1 Entry must be restricted to authorized laboratory and maintenance staff and other persons on official business.

4.2.1.2 Entry to PPC-2 arthropod containment zones must be restricted to authorized laboratory staff, maintenance staff and other persons on official business. Access to specific areas within these containment zones must be granted on an "as needed" basis only.

4.2.2 Documentation

4.2.2.1 A Procedures Manual covering safety and general laboratory and greenhouse operations including entry and exit protocols and cleaning schedules must be available to all staff, and its requirements followed; it must be reviewed and updated regularly. The Procedures Manual may consist of a series of Standard Operating Procedures.

4.2.2.2 An Emergency Response Plan must be available that describes emergency procedures, including those for accidents, fires, chemical spills, air handling failure, BSC failure, power loss and containment loss. Plans must cover emergency entry/exit procedures, corrective actions and notification of key personnel and government officials.

4.2.2.3 The Laboratory Director (LD) or their designate(s) such as supervisors are responsible for:

- organisms that enter, are held within, or leave the containment zone;
- compliance with all regulatory requirements;
- maintenance of SOPs and Procedures Manuals;
- compliance with SOPs and the Procedures Manual; and
- determining who is authorized to work in the facility.

4.2.2.4 Records shall be kept of activities in the facility for three years, including records of all building and equipment maintenance, shipments received, confirmations of pest identification, dates of import, CFIA Permits to Import, associated imported plant material, associated organisms detected, decontamination of packaging materials and transfer of plant pests or organisms to other facilities where authorized by a CFIA Inspector. Records shall also be kept of all inoculations or infestations of plant material and the movement of plant material and plant pests into or out of containment.

4.2.2.5 Appropriate signage indicating the nature of the plant pests/organisms being used (i.e. type and containment level) must be posted on the inner entry door to each laboratory. If there are special provisions for entry, the relevant information must be included on the sign; the contact information of the laboratory supervisor or other responsible person(s) must be listed.

4.2.3 Training

4.2.3.1 Personnel working in the containment zone must be trained in, and follow, the Standard Operating Procedures for the area. Trainees must be supervised by a trained staff member. Visitors, maintenance staff, janitorial staff, and others must be provided with training and/or supervision commensurate with their anticipated activities in the containment zone.

4.2.4 Personal Protective Equipment

4.2.4.1 Personnel entering the containment zone may need to wear protective clothing up to and including full coverage protective clothing. All protective clothing must be removed prior to exiting the containment zone.

4.2.4.2 Dedicated or disposable footwear (e.g. rubber boots, shoe covers) should be worn when working with soil or soil-borne pests where potentially infested plant material or soil may contaminate the floor. Where such footwear is used, it must be removed for reuse or decontamination prior to exiting the containment zone.

4.2.4.3 Where appropriate, BSCs or other primary containment devices are to be used for procedures involving potential allergens and for procedures that involve high concentrations or large volumes of plant pests or their propagules.

4.2.5 Work Practices

4.2.5.1 Personnel must not bring unnecessary personal belongings (e.g. hats, coats, purses) into the containment zone if there is a risk that these items could harbour pests on exit, resulting in a loss of containment.

4.2.5.2 Laboratory doors must be kept closed as required by the facility design.

4.2.5.3 To minimize places where plant pests can persist, avoid using containment zones for general storage of items not used in that area.

4.2.5.4 To facilitate minor repairs, a basic tool kit should always be available inside the containment zone.

4.2.5.5 Packages of pests from foreign sources must be opened in a BSC or a sleeved cage, as appropriate and packaging material must be decontaminated as soon as possible.

4.2.5.6 Where appropriate, footbaths (e.g. trays containing cloth pads soaked in disinfectant) must be located in the anteroom of facilities containing soil borne pests, to disinfect footwear, shoe covers or dedicated footwear.

4.2.5.7 If there is a risk of disseminating pests in clothing known to be or suspected of being contaminated, such clothing must be decontaminated (e.g. heat treated, frozen, autoclaved or soaked in a 5% bleach solution) before laundering. Clothing does not need to be decontaminated if laundering facilities are within the containment zone and the facilities have been proven to be effective in killing the pests in use.

4.2.5.8 If there is a risk of disseminating pests with the movement of paper, use an electronic communication system to transfer information and data from the containment zone.

4.2.5.9 All contaminated materials, solid or liquid, including soil from soil traps, must be decontaminated using validated methods before disposal or reuse. Wastes should be sterilized in a timely manner and not allowed to

accumulate and decay.

4.2.5.10 All liquids potentially contaminated by pests must be decontaminated. Liquids must be collected and treated with steam, heat, chemicals, or other proven and validated treatment technology prior to discharge into sewer or septic systems.

4.2.5.11 Periodic inspections of the containment zone must be made by facility staff to check for faults and deterioration (e.g. deteriorated door seals and brushes, screens or caulking); corrective action must be taken and records kept for three years. Such inspections shall occur at least every six months.

4.2.5.12 Supply and exhaust filters, pre-filters and screens are to be inspected and cleaned or replaced by a designated person on a regular basis.

4.2.5.13 Where applicable, inward directional airflow must be confirmed on a regular basis using a smoke pencil, tape, tissue or other suitable means.

4.2.5.14 An effective and appropriate monitoring system (e.g. insect traps, spore traps, susceptible sentinel host plants) and pest control program should be in place to control undesired pests and to detect escaped pests.

4.2.5.15 Inspect all plant material and insect traps on a regular basis. Remove all debris and dead plant material so that it does not act as a refuge for plant pests.

4.2.5.16 Keep areas surrounding greenhouses free of debris, garbage, compost piles and overhanging shrubs and trees.

4.2.5.17 Where appropriate, staff must examine themselves, or be examined by others, for hitchhiking arthropods prior to exiting the containment zone. Hitchhiking arthropods must be removed or killed before exit.

4.3 PPC-3 Practices

All operational practices for PPC-1 and PPC-2 level containment facilities apply to PPC-3 facilities. The following sections describe the additional minimum operational practices required in PPC-3 containment facilities.

4.3.1 Access

Entry to the containment zone must be restricted to authorized laboratory staff, maintenance staff and others on official business. Access to specific areas within the containment zone must be granted on an “as needed” basis only.

4.3.2 Documentation

4.3.2.1 The Laboratory Director (LD) or their designate is responsible for all

organisms that enter, are held within, or leave the facility; compliance with all regulatory requirements, including permit requirements; maintenance of the Standard Operating Procedures (SOP) manual; ensuring compliance with the SOP manual; and determining who is authorized to work in the facility.

4.3.2.2 The LD or their designate is responsible for the SOP manual that includes procedures specific to the operation of the facility. It must be kept current, and employees must certify that they have understood and agree to abide by relevant SOPs. The SOP manual must include policies and procedures for the following:

- entry of authorized personnel;
- receipt of exotic material;
- organism handling;
- waste disposal;
- identification of received pests;
- record keeping;
- housekeeping, cleaning and disinfection;
- entry, exit and decontamination protocols for equipment, samples, and solid and liquid waste;
- cleaning soil traps and disposing of contents;
- monitoring of visitors;
- monitoring for pest escapes;
- emergency contacts;
- operation, repair and maintenance of air handing systems;
- operation, repair and maintenance of waste treatment systems;
- emergency repair procedures;
- training of staff;
- use of equipment; and
- inoculation of plants.

4.3.2.3 The above SOPs are to be supplemented with SOPs specific to the nature of the work being conducted and to each project or activity as appropriate.

4.3.2.4 A log book of all people entering and leaving the facility must be maintained and kept for three years.

4.3.3 Training

4.3.3.1 Personnel entering the containment zone must have completed training in the procedures specific to the containment zone and must show evidence of having understood the training; training must be documented and signed by the employee and supervisor.

4.3.3.2 Personnel must demonstrate proficiency in appropriate practices (SOPs)

and techniques.

4.3.3.3 Personnel working in the containment zone must possess knowledge of the physical operation and design of the facility (e.g. air pressure gradients between zones, directional airflow patterns, alarm signals for air pressure failure, and the containment perimeter).

4.3.4 Personal Protective Equipment

4.3.4.1 Personnel entering the containment zone must remove street clothing, jewelry, etc., and change into dedicated laboratory clothing and shoes; dedicated laboratory clothing and shoes must be removed in a manner that minimizes the potential transfer of pests from potentially contaminated laboratory clothing before leaving the containment zone. The use of full coverage protective clothing (i.e. completely covering all street clothing and hair) may be an acceptable alternative. Personnel must wash their face and hands prior to exiting the containment zone.

4.3.4.2 In the event of life-threatening emergencies, personal health and safety are a priority. Exit protocols must have been established in advance whereby routine procedures may be bypassed while maintaining pest containment as much as possible.

4.3.5 Work Practices

4.3.5.1 Personnel entering a containment zone should make an effort to bring all materials they will need with them; if something has been forgotten, established traffic patterns must still be adhered to (i.e. either telephone for someone to bring it in, or exit using proper protocols).

4.3.5.2 If an aerosol exposure to pests would present a risk of pest escape, protocols must be in place to determine whether showering is required on exit from the containment zone.

4.3.5.3 Smoke testing (i.e. using a smoke pencil held at the door between the anteroom and the containment zone, and other doors as required) is to be done periodically by staff to verify inward directional airflow.

4.3.5.4 A containment check must always be performed before entering the containment zone (i.e. verify correct reading(s) on the pressure monitoring device(s)).

4.3.5.5 Routine cleaning must be done by personnel using the containment zone, or by other personnel specifically trained for this task, in order to minimize the number of people exposed to the pests under containment and thus the possibility of pest escape.

4.3.5.6 The containment zone must be kept locked and all doors must remain

closed when not in use.

4.3.5.7 Work with plant pests in open vessels on open benches must be kept to a minimum.

4.3.5.8 Viable plant pests must be either stored inside the containment zone, or kept in leak-proof containers which are placed in locked storage located outside of the containment zone.

4.3.5.9 Drain traps must be kept filled with water or disinfectant (e.g. through regular sink usage, automatic primers or by filling traps in areas that are not frequently used).

4.3.5.10 Samples and supplies may be carried into the containment zone or passed in through a **pass-box** system with interlocking doors. If the barrier autoclave is used to pass materials into the laboratory, the autoclave must have been cycled before the outer "clean side" door is opened.

4.3.5.11 A pass-box may be used to remove non-viable organisms and DNA, and decontaminated materials, supplies and equipment that cannot withstand autoclaving from the containment zone.

4.3.5.12 Centrifugation of infectious materials must be carried out in closed containers. The use of sealed centrifuge tubes inside sealed cups is recommended and these should be opened within a BSC.

4.3.5.13 Plants or arthropods that have been experimentally infected or infested must remain in the containment zone or be decontaminated or disinfected prior to removal or disposal.

4.3.5.14 All contaminated material (e.g. glassware, laboratory clothing, waste material) must be decontaminated before cleaning, reuse or disposal. Waste must be decontaminated at the containment barrier before disposal; both doors of a pass-through sterilizer must not be opened simultaneously. Use of a single door autoclave may be acceptable, based on the results of a risk assessment.

4.3.5.15 CFIA authorities must be notified of any planned structural or containment changes to the facility.

5. Decontamination Processes

Decontamination methods used for all contaminated or potentially contaminated materials (e.g. rearing materials, infected or infested plant materials, cultures) must be validated. Depending on the particular organism and life stage of concern, decontamination may be achieved by methods such as hot water immersion, freezing, rapid heating, drying, dry heating, steaming, autoclaving, fumigation or chemical disinfection. All decontamination and waste management procedures must be in accordance with applicable federal, provincial and municipal regulations.

6. Facility Certification

When appropriate, CFIA Inspectors may conduct site visits and certify facilities as meeting these standards to ensure that they are constructed in a manner that adequately contains plant pests.

6.1 Certification

Laboratories handling plant pests should refer to chapters 3 and 4 of these Standards to verify that their operational practices and physical containment are adequate to contain the pests that will be used there. In order to receive a Permit to Import, PPC-2 and PPC-3 facilities must be certified by the CFIA. Facilities importing pests and planning work that requires PPC-2 containment may be inspected by CFIA Inspectors, and/or facility staff may be required to fill in a detailed inspection checklist. Facilities importing pests and planning work that requires PPC-3 containment will undergo an initial inspection by CFIA Inspectors. Certifications are valid for a period of two years. If a facility's certification is not granted, or is revoked for any reason, the deficiency, or deficiencies, must be corrected before the facility can be certified or re-certified.

The critical containment components to be verified during initial certification of PPC-3 facilities are provided in section 6.3. All of these components are to be verified during the commissioning of a new facility. Certification and re-certification records must be retained for three years and they must be available for review by a CFIA Inspector, who may elect to re-verify some or all of the components. All as built drawings of the PPC-3 facility with specifications of surfaces must be submitted for review. Operational protocols must be submitted for review before work with plant pests at the PPC-3 level can be carried out. Training of personnel must be completed and documented. Users must understand containment principles and proposed procedures. Detailed records of the certification process and test reports for PPC-2 and PPC-3 facilities must kept for three years.

6.2 Re-certification

Re-certification of PPC-3 facilities must initially be conducted annually. Detailed records and test reports are required for re-certification and these must be retained for three years. Before **program changes** are implemented at PPC-3 facilities, operational procedures must be submitted for review and approval by the CFIA. Program changes

include those related to the nature of work, or procedures employed, that would increase the risk of pest escape from the facility.

6.3 Verification and Performance Testing of PPC-3 Facilities

6.3.1 Room Integrity

Room integrity is to be verified by smoke testing the room perimeter to detect leaks. All joints, corners and sealed penetrations are to be smoke tested for leaks.

6.3.2 Air Handling Systems

Particle challenge testing of HEPA filters is to be performed *in situ* by the particle scanning method to ensure they do not contain leaks in the filter media, the bond between the media and frame, or around the frame gasket and support. Particle penetration is not to exceed 0.01%.

Ductwork systems are to be pressure decay tested to confirm that leakage rates do not exceed 0.2% of duct vol/min at 500 Pa. The American Society of Mechanical Engineers (ASME) Standard N510 *Testing of Nuclear Air Treatment Systems,* 1989, gives procedures for testing the leak-tightness of ducts and plenums.

Room pressure control systems are to operate as specified (i.e. ensure negative pressures are maintained). Control systems are to be tested for fail-safe operation by failure of system components. Alarms are to be tested for the detection of positive pressurization and air handling systems failure by simulation of alarm conditions.

6.3.3 Fume hoods

Fume hoods and associated exhaust systems are to comply with relevant design and installation requirements and they must be tested *in situ* in accordance with CSA Z316.5-04, *Fume Hoods and Associated Exhaust Systems* (2004). Fume hoods are to comply with the requirements for HEPA filtration. The installation of a charcoal filter prior to the HEPA filter may be considered as a measure to protect the HEPA filter from deleterious effects of chemical vapours and also as protection for personnel performing maintenance and certification testing of the HEPA filter.

6.3.4 Biological Safety Cabinets

Testing and certification of BSCs shall be performed in accordance with CSA Z316.3-95 or the applicable NSF Standard. Interlocks (i.e. Class II Type B2 BSC internal cabinet supply fan and exhaust fan) are to be tested in accordance with the applicable NSF standard. Manufacturer's requirements for airflows for BSCs must be met.

6.3.5 Emergency Power

Emergency electrical generators must be tested under appropriate load conditions to ensure systems will operate as specified.

6.3.6 Surface Finishes

Benches, casework, walls and floors are to be inspected to determine whether they are cleanable and can withstand decontamination methods. Where applicable, surfaces should be continuous and without seams to allow for thorough cleaning and decontamination, and penetrations must be sealed.

6.3.7 Communication Devices

Where they are present, communication and electronic data transfer systems (e.g. computer, telephone, facsimile) are to be tested to ensure that they will operate as specified.

6.3.8 Access Control / Security Devices

Security systems (e.g. controlled access) must be tested/verified to ensure that they will operate as specified.

6.3.9 Autoclaves and Decontamination Systems

All treatment systems (e.g. autoclaves, liquid effluent treatment systems) must be verified for operation as specified, and tested using representative loads. Biological indicators or an internal load temperature probe should be used to confirm that treatment parameters have been achieved. All other decontamination systems (e.g. dunk tanks, gas sterilizers) are to be tested for operation as specified. References pertaining to the maintenance and efficacy of decontamination systems and disinfectants must be kept for three years. A description of the procedure to be followed must be provided to the CFIA.

6.3.10 Effluent Treatment Plumbing

Drains and associated piping leading to liquid effluent treatment systems (including associated vent lines) must be tested in accordance with Section 3.6 of the National Plumbing Code of Canada (1995).

6.3.11 Standard Operating Procedures

Standard operating procedures for the facility must be updated on a regular basis, and updated SOPs must be submitted to the CFIA at the time of re-certification.

7. Contact Information

For information regarding the Containment Standards for Facilities Handling Plant Pests please contact:

Biohazard Containment and Safety Unit,
Canadian Food Inspection Agency
159 Cleopatra Drive
Ottawa ON
K1A 0Y9
Tel. (613) 221-7068
Fax (613) 228-6129
http://www.inspection.gc.ca/english/sci/bio/bioe.shtml

For information regarding Permits to Import for plant pests please contact:

Plant Health Division,
Permit Office,
Canadian Food Inspection Agency
59 Camelot Drive
Ottawa, ON
K1A 0Y9
Tel. (613) 225-2342
Fax (613) 228-6605
http://www.inspection.gc.ca/english/plaveg/internat/internate.shtml#2

8. Glossary

Biological control (Biocontrol)	Pest control strategy making use of living natural enemies, antagonists, or competitors and other self-replicating biotic entities (IPPC, 2004).
Biological control agent	A natural enemy, antagonist or competitor, and other self-replicating biotic entity used for pest control (IPPC, 2004).
Biological safety cabinet (BSC)	A primary containment device that provides personnel, environmental, and, in some cases, product protection from airborne or aerosolized microorganisms. BSCs consist of a leak-tight box, HEPA filter(s) and a motor/blower system to provide controlled air movement through the box and filters.
Containment	Restricting plant pests to their intended locations through the use of operational procedures, physical barriers and facility design.
Containment facility	A structure whose purpose is to prevent escape of material held within it, into the environment (NAPPO 2005).
Containment perimeter	The continuous floor, ceiling and wall surfaces that form a barrier against the ingress or egress of plant pests including all windows, doors and service penetrations into the area.
Containment zone	A contiguous physical area within a physical structure that meets specified containment requirements.
Decontaminate	To render a plant pest non-viable.
Facility	Laboratories, greenhouses, screenhouses, growth chambers and other supporting structures and buildings.
Greenhouse	A structure with a floor and transparent walls and roof designed and used principally for

	growing plants in a controlled and protected environment.
Growth chamber	A mechanical device designed to provide a suitable environment for growing plants under controlled light, and temperature conditions.
Growth room	A structure with walls, a roof and a floor designed and used principally for growing plants or other organisms in a controlled and protected environment (VLAREM II 2005).
Headerhouse	A building connected to one or more greenhouses that may include laboratories, offices, storage and greenhouse support areas.
HEPA filter	High Efficiency Particulate Air filters with a minimum efficiency of 99.97% at 0.3 µm.
Inward directional airflow	Airflow created by a ventilation system such that air will always flow to areas of higher risk of contamination (e.g. 12.5 – 25 Pa differential).
Kneewall	A partial-height solid wall in a greenhouse that is placed to minimize the possibility of glass breakage.
Pass-box	A sealed box with two doors constructed through, and sealed to the containment perimeter. The box is equipped with interlocking doors (preferred), or audible or visual alarms to prevent, or deter, the simultaneous opening of both doors.
Plant pest	Any thing that is injurious or potentially injurious, whether directly or indirectly, to plants or to products or by-products of plants, and includes any plant prescribed as a pest [PPA 1990]. This includes any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products (IPPC 2004) including, but not limited to, arthropods, molluscs, bacteria, nematodes,

	fungi, phytoplasmas, viruses, and viroids.
Primary containment	The protection of hosts within the containment zone from exposure to plant pests. Primary containment is provided by good microbiological technique that avoids the release of pests into the zone and the use of appropriate primary containment devices such as BSCs and insect cages.
Program change	A change in a PPC-3 facility related to the nature of work, or procedures employed, that would increase the risk of pest escape from the facility.
Screenhouse	A structure with a roof, floor and screened walls, designed and used principally for growing plants in a protected environment.
Secondary containment	The protection of hosts outside of the containment zone from exposure to plant pests. Secondary containment is provided by the resistance of the containment zone to the active or passive movement of pests combined with good operational practices.
Standard operating procedures (SOPs)	Documents that describe the procedures used for a specific task.
Validated	Demonstrated to be fit for a specific purpose.

9. Selected References

AAFC. 1996. *Containment Standards for Veterinary Facilities, First Edition (AAFC Pub. No. 1921/E).* Agriculture and Agri-Food Canada, Food Production & Inspection Branch (FPIB), 71 pp.

Adair, D., Ruth Irwin, Patricia L. Traynor. 2001. *A Practical Guide to Containment Greenhouse Research with Transgenic Plants and Microbes.* Information Systems for Biotechnology, Blacksburg, VA. 59pp.

American Society of Mechanical Engineers. 1989. *Testing of Nuclear Air Treatment Systems.* ASME N510. New York, NY.

ANSI/AIHA. 1992: American National Standards Institute/American Industrial Hygiene Association *Z-9.5-1992: Standard for Laboratory Ventilation*. Fairfax, VA. 23 pp.

AS/NZS 2002. 2243.3:2002. *Australian/New Zealand Standard: Safety in Laboratories, Part3: Microbiological aspects and containment facilities*. Standards Australia/Standards New Zealand, Sidney, Australia, Wellington, New Zealand. 108pp.

ARS. 2001. *Standard Operating Procedures at the PLANT PATHOLOGY CONTAINMENT FACILITY. United States Department of Agriculture, Agricultural Research Service, Foreign Disease-Weed Science Research Unit.* Sept. 25 2001. 54pp.

Bailey, J.C. and J.B. Kreasky. 1978. *Quarantine Laboratory for Plant Feeding Insects*. Pages 53-56. In: *Facilities for Insect Research and Production*. United States Department of Agriculture Technical Bulletin Number 1576. 86pp.

Baldwin, J.G., M. Monson and E. Paine. 1999. *University of California (Riverside) Quarantine and Isolation Facility for Soil and Water Nematodes*. Pages 166-181. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests*. R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

Canadian Standards Association. 1995. *Biological Containment Cabinets: Installation and Field Testing.* CSA Z316.3-95. Toronto, ON.

Canadian Standards Association. 2004. *Fume Hoods and Associated Exhaust Systems.* Z316.5-94. Toronto, ON.

CSIRO 2005. *Black Mountain Quarantine Facility*. http://www.ento.csiro.au/quarantine/quarantine.html. Commonwealth Science and Industrial Research Organisation, Australia.

Damsteegt, V.D., W.L. Bruckart, M.R. Bonde, R.A. Creager, D.G. Luster, S.M. Yang, N.W. Shaad. 1999. *Containment Research with Foreign Plant Pathogens*. Pages 161-165. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests.*

R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

De Clerck-Floate, R., P. Plue and T. Lee. 2000. *Lessons Learned During the Design of an Arthropod and Pathogen Quarantine Facility*. Pages 437-447. In: Proceedings of the X International Symposium on Biological Control of Weeds, 4-14 July 1999, Montana State University, Bozeman, MT, USA. Neal R. Spenser [ed.].

De Clerck-Floate, R.A., P.G. Mason, D.J. Parker, D.R.Gillespie, A.B. Broadbent and G. Boivin. 2006. *Guide for the Importation and Release of Arthropod Biological Control Agents in Canada*. AAFC publication, Ottawa In Press.

Denmark, H.A. 1978. *Quarantine and Biological Control Laboratory*. Pages 47–49. In: *Facilities for Insect Research and Production*. United States Department of Agriculture Technical Bulletin Number 1576. 86pp.

Ertle, L.R. and W.H. Day. 1978. *USDA Quarantine Facility, Newark, Delaware*. Pages 49-52. In: *Facilities for Insect Research and Production*. United States Department of Agriculture Technical Bulletin Number 1576. 86pp.

EC. 1995. European Commission Directive 95/44/EC, *Establishing the conditions under which certain harmful organisms, plants, plant products and other objects listed in Annexes I to Council Directive 77/93/EEC may be introduced into or moved within the Community or certain protected zones thereof, for trial or scientific purposes and for the work of varietal selections*. 26 July, 1995. 15pp.

Fisher, T.W. 1978. *University of California Quarantine Facility, Riverside*. Pages 56–60. In: *Facilities for Insect Research and Production*. United States Department of Agriculture Technical Bulletin Number 1576. 86pp.

Gumpf, D.J. 1999. *Citrus Quarantine, California*. Pages 151-156. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests*. R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

HC. 2004. *Laboratory Biosafety Guidelines, 3rd Edition*, pub. Ministry of Health, Population and Public Health Branch, Centre for Emergency Preparedness and Response (H39-4/49-2004E). 113 pp.

Howell, W.E. and G. Mink. 1999. *NRSP-5/IR-2 Program to Develop and Distribute Virus-Tested Deciduous Fruit Tree Clones*. Pages 157-160. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests*. R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

International Plant Protection Convention (IPPC). 2004. Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome. International Standards for Phytosanitary Measures, *Glossary of Phytosanitary Terms*. Publication No. 5, April 2004. 76 pp.

Jenniskens, M.J. 1992. *The Netherlands: Quarantine Facilities*. Plant Protection Service the Netherlands 14pp.

Kang, S.M.1999. *Quarantine Insectary*. Pages 191-193. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests*. R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

Leppla, N.C. and W.G. Eden. 1999. *Facilities and Procedures to Prevent the Escape of Insects from Large-Scale Rearing Operations*. Pages 186-190. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests*. R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

MAF. 1998. *MAF Regulatory Authority Standard 155.04.03: Specification for the Registration of a Plant Pest Diagnostic Laboratory, and Operator*. MAF Regulatory Authority, Ministry of Agriculture and Forestry, P.O. Box 2526, Wellington, New Zealand. 20 pp.

MAF. 1999. *MAF Biosecurity Authority Standard PBC-NZ-TRA-PQCON: Specification for the Registration of a Plant Quarantine or Containment Facility, and Operator*. MAF Biosecurity Authority, Ministry of Agriculture and Forestry, P.O. Box 2526, Wellington, New Zealand. 36pp.

MAF. 2002. *MAF Biosecurity Authority Standard 154.03.02: Containment Facilities for Microorgansims*. MAF Biosecurity Authority, Ministry of Agriculture and Forestry, P.O. Box 2526, Wellington, New Zealand. 24pp.

MAF. 2002. *MAF Biosecurity Authority Standard 154.02.08: Transitional and Containment Facilities for Invertebrates*. MAF Biosecurity Authority, Ministry of Agriculture and Forestry, P.O. Box 2526, Wellington, New Zealand. 24pp.

Mason, P. and J. Huber (eds.) 2002. *Biological Control Programmes against Insect and Weeds in Canada 1981-2000.* Commonwealth Agricultural Bureaux, Slough, UK. 583 pp.

McFadyen, R.E.C. 1998. *Biological control of weeds*. Annual Review of Entomology. 43:369-93.

NAPPO. 2004. North American Plant Protection Organization Regional Standard for Phytosanitary Measures (RSPM) No. 22: *Guidelines for the Construction and Operation of a Containment Facility for Insects and Mites used as Biological Control Agents*. 9pp.

NAPPO. 2005. North American Plant Protection Organization. E-mail dated October 31, 2005.

National Research Council. 1995**.** *National plumbing code of Canada*. Ottawa, ON:

Canadian Commission on Building and Fire Codes.

NIH. 2002. *National Institutes of Health Guidelines for Research Involving Recombinant DNA Molecules*. (http://www4.od.nih.gov/oba/rac/guidelines_02/NIH_Gdlnes_lnk_2002z.pdf) April 2002.

NFPA. 1991. National Fire Protection Association. *45: Fire Protection for Laboratories Using Chemicals.* Quincy MA.

NSF International. 2002. *Class II (laminar flow) biohazard cabinetry.* Standard 49. Ann Arbor, MI.

Plant Protection Act 1990. C.22 (Canada)

PPD. 1994. Plant Protection Directorate, Plant Pathology Service, *Quarantine Station Work Procedures and Guidelines*. Diagnostic and Quarantine Division, Quarantine and Resistance Policy Coordination Section, Agriculture, Nature Conservation and Fishery. The Netherlands. 76pp.

Rashid, K.Y. and E.O. Kenaschuk. 1991. *A flax rust containment research laboratory at Agriculture Canada Research Station, Morden, Manitoba*. Can. J. Plant Pathol. 13: 93-95.

Roosjen, M.G., M. Stigter, and P.A. Oomen. 1999. *Greenhouse Pest Exclusion and Eradication Safeguards and Principles*. Pages 182-185. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests*. R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

Rose, M. 1995. *The Biological Control Quarantine Laboratory*. Texas A&M University, Department of Entomology. 23pp.

Sheet Metal and Air Conditioning National Association, Inc. 1985. *HVAC air duct leakage test manual*. Chantilly, VA.

Singh, B.P. 1999. *High-Security Containment Facilities in the United States for Fungal Plant Pathogens of Quarantine Significance.* Pages 194-204. In: *Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests*. R.P. Kahn and S.B. Mathur eds. APS Press, St. Paul, MN. 213 pp.

USDA. 2002. United States Department of Agriculture Research, Education and Economics, *ARS Facilities Design Standards*, July 24 2002. 19pp.

USDA-APHIS-PPQ. 2001. "*Draft Containment Guidelines for Nonindigenous, Phytophagous Arthropods and Their Parasitoids and Predators*". 13 pp.

USDA-APHIS-PPQ. 2001. "*Draft Containment Guidelines for Fungal Plant Pathogens*". 15 pp.

USDA-APHIS-PPQ. 2001. "*Draft Containment Guidelines for Viral Plant Pathogens and their Vectors*". 15 pp.

USDA-APHIS-PPQ. 2002. "*Draft Containment Guidelines for Noxious Weeds and Parasitic Plants*". 21pp.

USDA-APHIS-PPQ. 2003. "*Draft Containment Guidelines for Plant Pathogenic Nematodes*". 15 pp.

USDA-APHIS-PPQ. 2003. "*Draft Containment Guidelines for Plant Pathogenic Bacteria*". 14 pp.

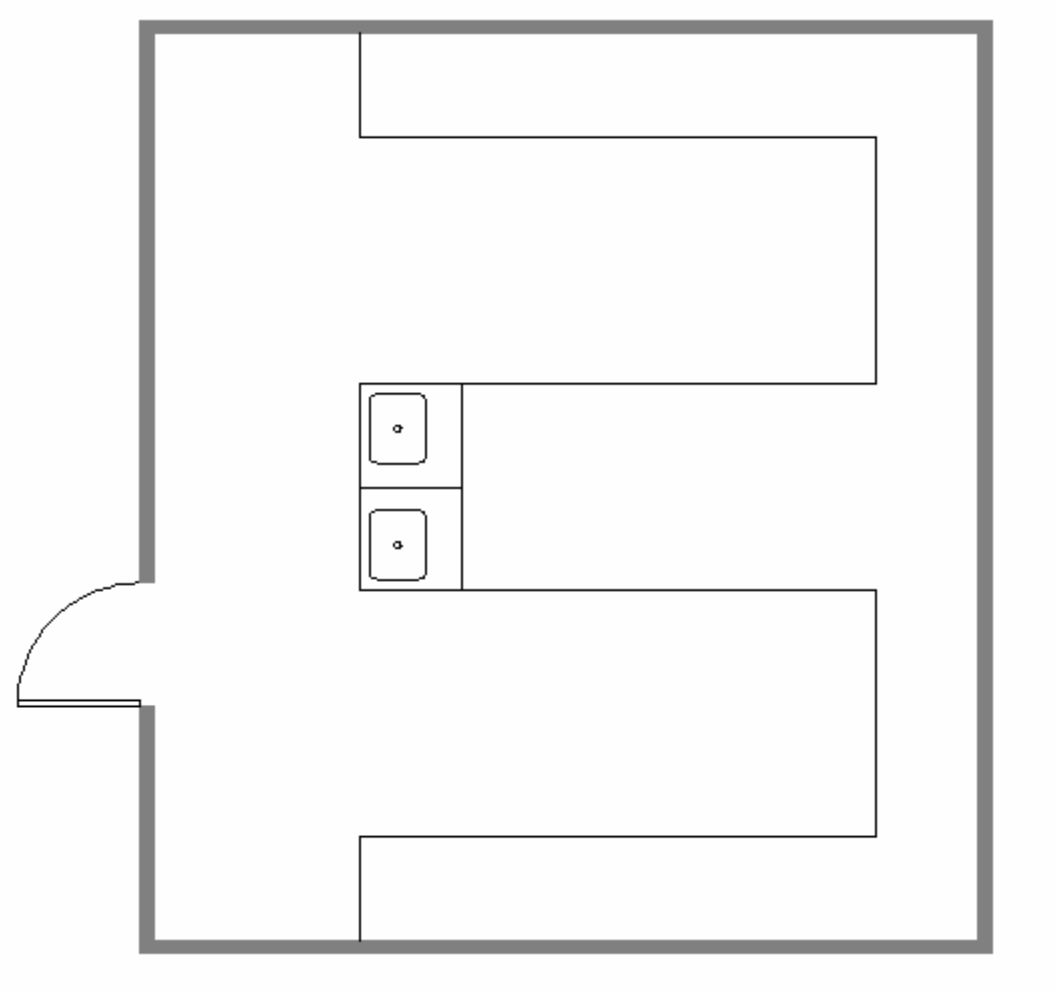
Watson, A.K. and W.E. Sackston. 1985. *Plant pathogen containment (quarantine) facility at Macdonald College*. Can. J. Plant Pathol. 7: 177-180.

VLAREM II 2005. *Appendix 5.51.4 Containment and Other Protective Measures.* http://www.emis.vito.be/wet_ENG_navigator/vlarem2_appendix_5_51_4.htm 2005-04-30. 25pp.

Appendix I

Simplified Examples of PPC-1, PPC-2 and PPC-3 Facilities

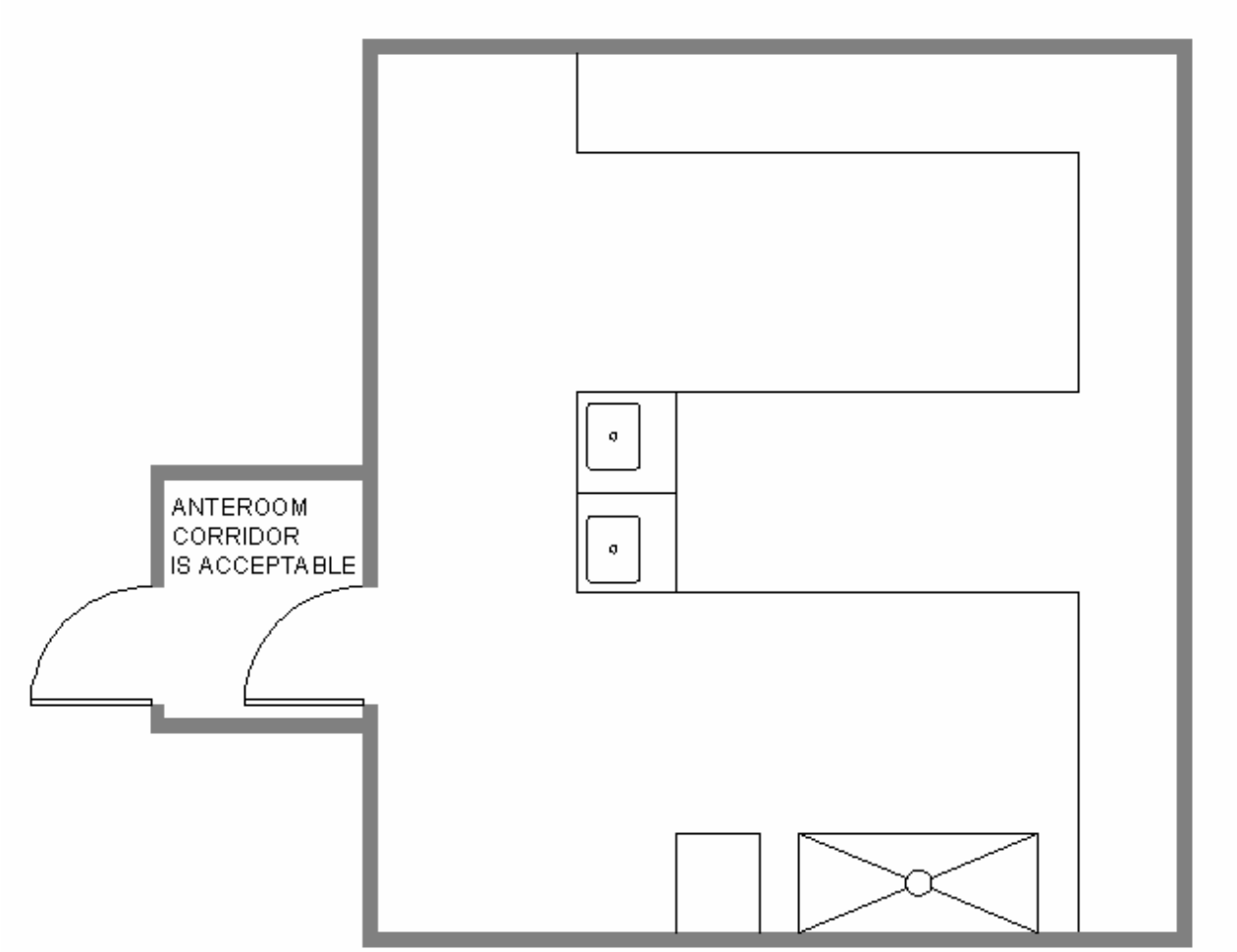
PPC-1



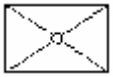
Appendix I

Simplified Examples of PPC-1, PPC-2 and PPC-3 Facilities

PPC-2



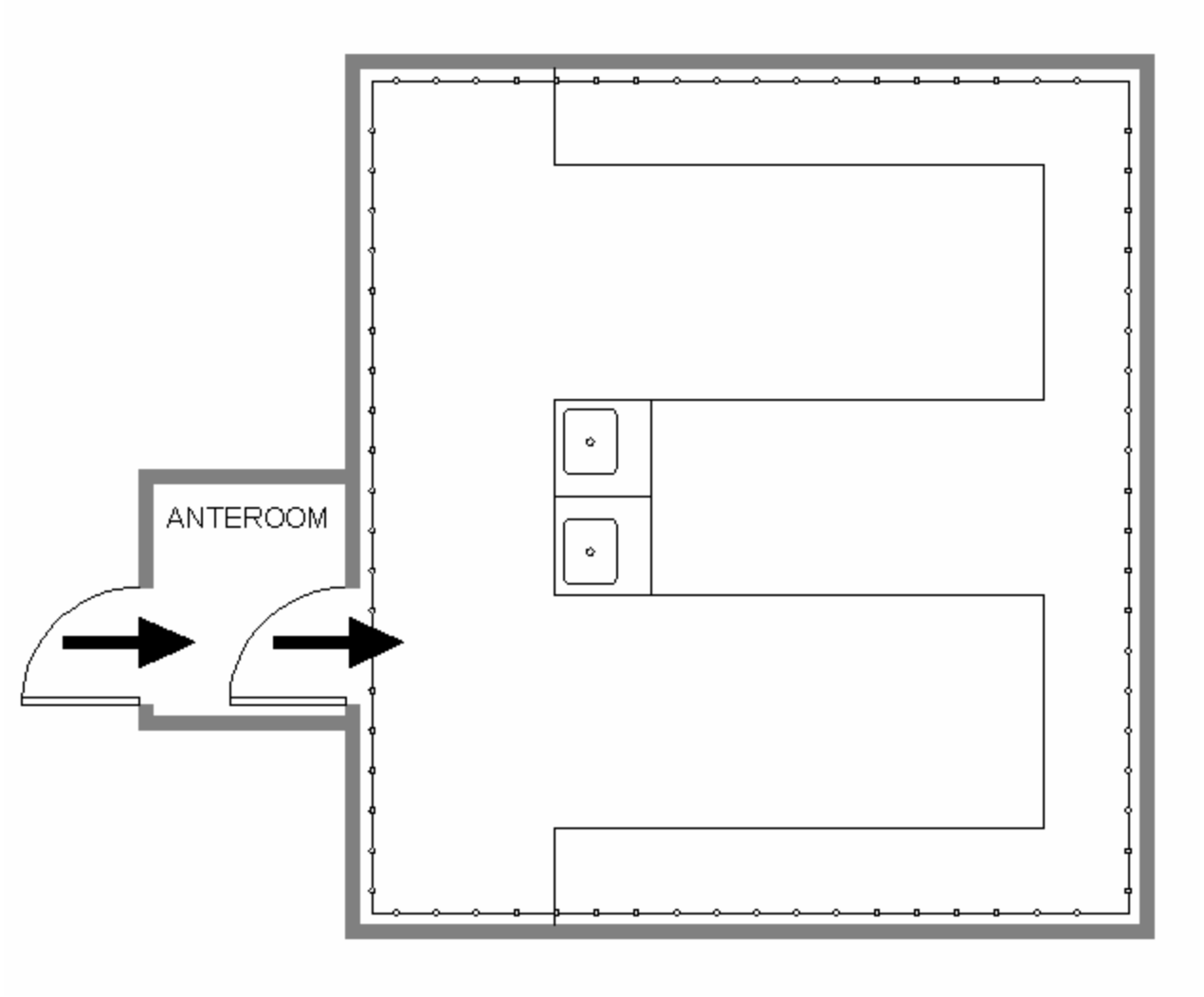
Legend

 Biological Safety Cabinet

Appendix I

Simplified Examples of PPC-1, PPC-2 and PPC-3 Facilities

PPC-2 Arthropod



Legend

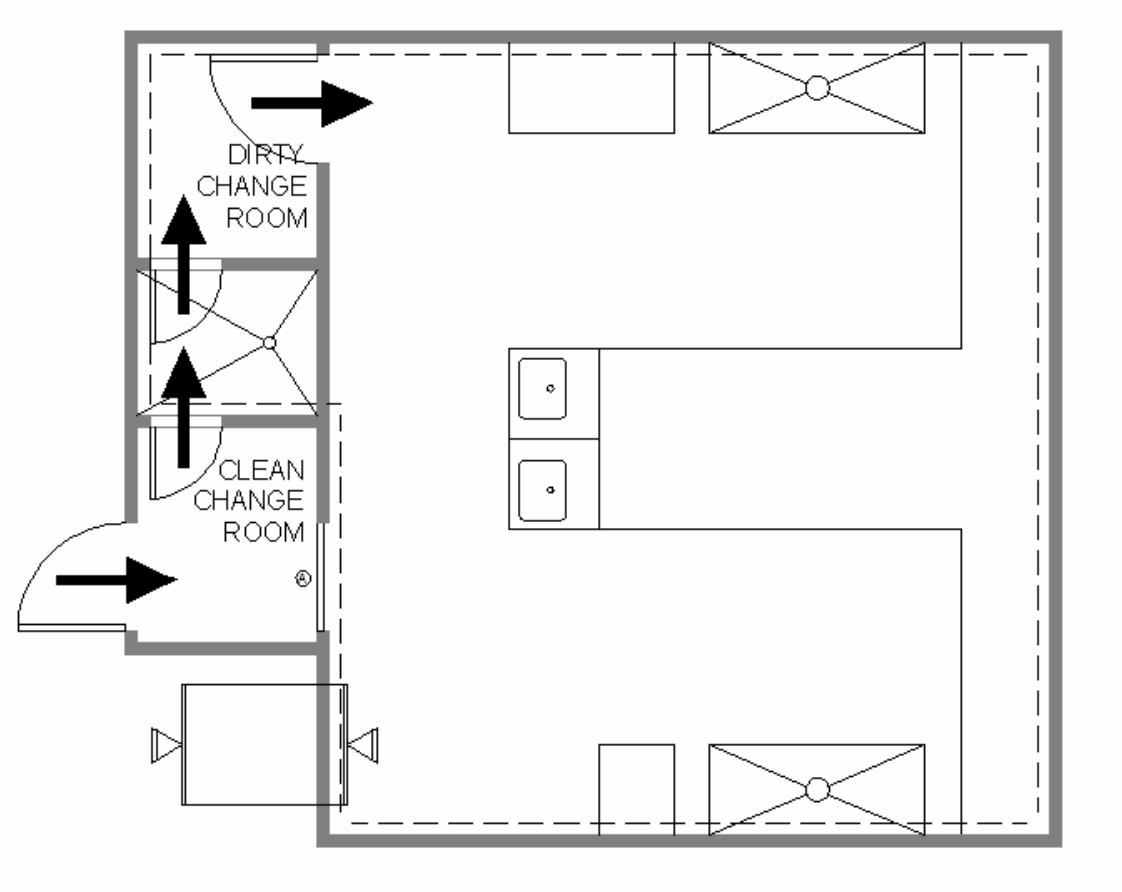
Airflow

Perimeter to prevent arthropod ingress and egress

Appendix I

Simplified Examples of PPC-1, PPC-2 and PPC-3 Facilities

PPC-3



LEGEND

Airflow

Shower

Biological Safety Cabinet

Sealed containment perimeter

Equipment entry

Double-door autoclave

Canada