Recommended biocontainment features for research and diagnostic facilities where animal pathogens are used

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Summary: Recommendations are presented for the minimum structural components, special utilities, installations, and other design and operational features which define a microbiologically-secure animal containment facility.

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These biocontainment parameters are expected to enable the safe housing and handling of livestock and poultry infected with pathogenic agents. Physical testing and certification requirements for commissioning such facilities are described. Such a facility will minimise personnel exposure to infectious agents, limit cross-contamination between experiments, minimise horizontal transmission between research animals, and reduce the likelihood of pathogenic agents being released to the outside environment.


INTRODUCTION

The role of a biocontainment facility includes protection of personnel, protection of research animals (1) and materials from cross-contamination, and prevention of environmental contamination.

This report is the consensus agreement reached by participants at the First International Veterinary Biosafety Workshop, held from 16 to 18 October 1991 in Knoxville, Tennessee, United States of America (USA). The purpose of this meeting was to assemble and coordinate international resources to identify minimum biocontainment features for the safe handling of pathogenic agents in laboratories and animal rooms. All participants were managers responsible for microbiological activities in biocontainment laboratories for research and diagnosis in animal and poultry disease. One of the tasks of the meeting was to consider and identify topics for discussion at the next such workshop, to be held at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian Animal Health Laboratory (AAHL) in Geelong, Victoria, in 1993.

For this report, the participants agreed to classify facilities into four biosafety levels (BL 1-4), for which recommended guidelines would be developed to indicate minimum requirements for facilities performing work with livestock and poultry pathogens (4, 6) presenting varying levels of risk. Basically, the four biosafety levels correspond to the risk level of the agent, with BL 4 representing the greatest risk.

With few exceptions, the adopted classification of facilities into BL 1-4 is in harmony with risk levels identified internationally (3, 4, 5, 6, 7, 8). Four existing systems for risk level designations and facility classification schemes were used to illustrate the concepts: the agent risk categories and corresponding biosafety levels are illustrated in Table I.

The characteristics of the pathogens designated as risk level 1 (Biosecurity Level 1, Risk Group 1, Class I and Risk Group I) may be broadly described as follows:

- unlikely to cause disease
- no deleterious impact on the environment
- minimal hazard to laboratory personnel.

Level 2 pathogens may be characterised as follows:

- causing mild disease
- modest economic impact
Comparison of disease agent risk categories and biosecurity facility classification

<table>
<thead>
<tr>
<th>Country/organisation</th>
<th>Disease agent risk</th>
<th>Facility</th>
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<tr>
<td>Australia</td>
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<td></td>
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<td>Risk Group III</td>
<td>Containment</td>
</tr>
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<td></td>
<td>Risk Group IV</td>
<td>Maximum containment</td>
</tr>
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</table>

E: exotic  
Z: zoonotic  
(a) non-indigenous pathogens of domestic livestock and poultry  
(b) facility use depends on agent, activity, and location of laboratory

- inherently rapid biological decay rate
- limited survival in the environment (only one seasonal change)
- minimal hazard to personnel
- not horizontally transmitted
- readily treated with antibiotics
- may be prevented through readily-available measures
- indigenous or endemic in the country.

Level 3 covers pathogens with the following characteristics:  
- may cause a serious disease
- economic impact of more than US$50 million
- easily transmitted by aerosols
- may be medically treated and prevented through readily-available measures
- may be prevented through the use of available vaccines
- may infect large numbers of livestock, poultry or humans
- occasionally lethal consequences
- indigenous or endemic in the country.

Pathogens designated as level 4 possess the following characteristics:
- causing a very serious disease
- high mortality rate
- high risk to personnel
- readily transmitted by aerosols or transmitted by arthropods
- often no effective vaccine
- limited or ineffective medical treatment regimes or preventive measures to ward off infection
- may be indigenous, endemic or exotic to the country
- often also causing diseases of humans.

The designation of Class 5 agents in the USA is reserved for non-indigenous pathogens of domestic livestock and poultry or exotic strains of endemic disease (4). Class 5 agents are restricted by law, and possession requires a permit issued by the United States Department of Agriculture (USDA). These level 5 pathogens may be kept only at a special BL 3 or BL 4 Agricultural facility: they are readily transmitted via aerosols or transmitted by arthropods; effective vaccines are limited, and these pathogens are of major economic importance (possibly several billion US dollars).

This report focuses primarily on BL 3 Agricultural containment facilities, although certain required features of BL 4 facilities are also discussed. Each country employing these guidelines may use subsets within the four biosafety levels to address special requirements for complying with specific national regulations, individual laboratory guidelines, and the special requirements of the disease agents with which they work.

Minimum guidelines were developed to describe containment facilities (BL 3 and BL 4) which would be suitable for research with moderately and highly dangerous agents, respectively. The use of proper safeguards, indicated in the various biosafety guidelines, will minimise risks from aerosol infections. They are expected to prevent the spread of endemic or exotic diseases with potential serious or lethal effects on livestock, poultry or humans. There is also an economic incentive for the use of these biosafety standards, as they can help to prevent disruption of stable foreign and domestic agricultural markets.

The participants at this workshop judged that construction of a facility containing the features outlined below would enable personnel to work safely with both endemic and exotic pathogens of livestock or poultry. Additionally, the facility must be tested and certified, as outlined below, to ensure that containment of microorganisms is achieved by the construction practices. One cannot, however, rely on mechanical or structural features of the building alone. Together with the design of the facility, good laboratory practices, procedures and techniques, and the integration of sound animal care into each activity, are required. If zoonotic agents are used, the facility features described below may need to be supplemented with a Class III biological safety cabinet system, a
ventilated, self-contained personnel suite and/or the use of other protective equipment for personnel, and implementation of a comprehensive medical surveillance programme.

Use of exotic agents in a containment facility will depend on the identified need in the event of an identified disease outbreak, economic impact, public perception and acceptance, the need to develop vaccines or reagents, assessment of the potential for release of the pathogen from the facility and infection of susceptible livestock or poultry, and a comparative analysis of risk versus benefit.

MINIMUM FEATURES FOR BIOSAFETY LEVEL 3 AND 4 FACILITIES

The consensus agreement of minimum features for a BL 3 or BL 4 Agricultural containment facility are detailed below.

Design

The concept of the design should be that of a box within a box.

Animal cage

The animal room itself serves as the containment cage.

Integrity

Structural integrity should be demonstrated for the safe use of domestic or foreign epizootic and zoonotic disease agents.

Control signs

Signs warning of the hazards and entry requirements (immunisation and clothing) should be posted on access doors.

Surfaces

All interior surfaces should be uniform.

All impervious joints and surfaces should be sealed with a readily-cleanable, structurally-sound and chemically-resistant material which can withstand air-pressure differentials, temperature gradations and moisture.

Access

Access to animal facilities should be strictly controlled and restricted solely to assigned personnel and other personnel required to support the operation.

Access doors

Doors should have locks controlled by special pass keys (e.g. card key), fingerprint or eye identification, or numerical codes.

Airlock

An airlock should be provided for passage of materials or animals into the containment space.

Showers

Showers should be positioned near the animal room/area and used by personnel leaving this area.
Emergency showers and eyewash stations should be provided at strategic locations.

**Floors**

Floors should be structurally sound, rigid, non-slip, waterproof, chemically-resistant, seamless, stable at elevated temperature, easy to clean, suitable for use by different animal species, fitted with a coved base at the wall joint, and capable of being bonded permanently to the dissimilar surfaces encountered within the facility.

**Utilities**

The joints around all utility penetrations should be permanently sealed.

*Vacuum lines*

Vacuum lines should be fitted with in-line ‘high efficiency particulate air’ (HEPA) filters and, when necessary, a charcoal filter should be added.

*Air receiver tanks*

Air receiver tanks should be fitted with a HEPA filter and, when necessary, a charcoal filter should be added.

*Water*

Water lines should be fitted with a device to prevent back flow (either dual check valves or a dedicated break tank) to prevent laboratory water being siphoned back to the municipal or central on-site water source.

*Gas*

Gas supply (from a central or portable source) should be fitted with isolation valves, an in-line HEPA filter and/or charcoal filter, and appropriate one-way check or back-flow valves.

*Steam*

Steam should be provided at the work sites at both low pressure (up to 140 kPa) and high pressure (140-700 kPa).

*Drains*

Drains should be provided at central locations and around the perimeter of animal rooms.

A catchment basin should be provided to collect solids for appropriate decontamination and removal at a later time.

Floor drains should be equipped with ‘seal-off’ caps for ease of decontamination during and following the communal housing of research animals, and to isolate the rooms for renovations.

Each drain should have an in-line liquid U seal before being joined to the central drainage system.

**Communication**

Each area should be equipped with telephones at strategic locations, centralised computer terminal(s) and an emergency voice-activated loudspeaker system.

The emergency system should be connected to a central control station which is monitored by on-duty personnel or is capable of automatically alerting emergency personnel at remote locations.
Animal rooms/necropsy area

General

Waterproof electrical lamps, switches, junction boxes, communication systems (telephone, public address, etc.) should be provided in each animal room and necropsy zone.

Switches to disconnect the electrical supply to animal rooms and the necropsy area should be present both within and outside these areas.

Each area should be equipped with a voice-activated communication system.

Emergency lighting and emergency exits should be provided throughout the facility.

Showers for male and female personnel should be integral to each animal room, necropsy room, or set of rooms.

The facility design should be dependent on the disease agents, the experimental research programme, and the animal species to be used.

The door gasket on entrances/exits of animal rooms or necropsy areas can be made of non-porous material (which may be solid and rigid, or hollow and compressible); these gaskets should either have single or double friction-sealing surfaces, or be inflatable (using nitrogen or other inert gas).

Animal rooms

Animal rooms constructed to house large livestock should be fitted with anchored tie rings, isolation stanchions, loading chutes, pens/gates for restraining animals during examination or treatment, and central or portable hoists (either manually-operated or power-driven).

Isolation doors to animal rooms should be fitted with a non-breakable window, for personnel to observe the status of animals prior to entry, and a gasket to permit sealing of the door to the frame.

Necropsy area

The necropsy room or area should be adjacent to and have direct access to a pathological incinerator (carcass crematory) equipped with a central or portable hoist mechanism. The room should be designed to minimise aerosol generation and control any aerosols produced.

The necropsy room should have an integral cold room for long-term storage of animals awaiting necropsy or incineration. It should also have a fully-equipped support laboratory (adjacent to the animal rooms, cold room and pathological incinerator charge chute). This laboratory may be equipped with standard electrical components in keeping with local requirements.

The necropsy room should also have task lighting (for illumination of the work area), integrated communication systems, an operational decontamination chamber and integral personnel showers.

This room should be equipped with storage cabinets, a central autoclave, decontamination equipment, protective equipment for personnel and a supply of breathable air.
Corridors

Access to animal rooms should be either from a single corridor or from separate clean and dirty corridors.

Corridor(s) to the animal rooms/necropsy area should be equipped with a double-door entry/exit airlock which can serve as a decontamination chamber.

Sinks

Handwashing equipment (operated by foot, elbow, wrist or automatically) should be located within the rooms, near the exit door, or in the hallway in the suite exit area.

Alternatively, a complete body shower may be provided. This should form a separate transitional area between the contained zone and the clean area of the building.

Heating, ventilation and air conditioning

The heating, ventilation and air-conditioning (HVAC) systems should be designed and operated to provide directional air movement.

A minimum negative pressure differential of 12.5 Pa should be maintained between zones or rooms. The most hazardous zone (e.g. necropsy room) would be at the lowest pressure, and the entire building would be negative in relation to atmospheric pressure.

The air supply should be fitted with an in-line single HEPA filter, or equipped with mechanical controls or devices to prevent air release due to a reversal of directional air movement or high wind velocities.

Exhaust systems should have a single HEPA filter, with ample space for insertion of a second HEPA filter if this is deemed necessary for specific operations.

The design minimum exchange rate should be 10-12 air changes per hour. Air is not re-circulated in the containment facility.

To facilitate decontamination of animal or laboratory space, the HVAC should be fitted with equipment to adjust and control temperature between 16°C and 27°C, and relative humidity between 30% and 70%.

Decontamination/sterilisation

To aid decontamination/sterilisation, the facility should have a personnel entrance airlock, central autoclave, decontamination chamber (which can be a modified airlock), and a liquid effluent sterilisation system (operated as a continuous flow or batch system) and/or pasteurisation system (operated as a continuous flow or batch system).

Under certain research conditions, liquid chemical disinfectants could be acceptable for treatment of effluent from the facility.

The system for decontamination of equipment or refuse from the facility could be centralised.

Two alternative approaches for equipment decontamination are as follows:

a) use of collection containers or tanks for manual or automated operations
b) use of suitable chemical disinfectants (commensurate with the disease agents in use) to wash down surfaces or immerse equipment.
The test criteria for certification/commissioning of containment facilities are described below (see ‘Tests’ for details of test equipment and procedures).

**Filters**

HEPA filters and housings should be tested using a concentration of polydispersed dioctylphthalate (DOP) smoke particles. Fluids equivalent to DOP are food-grade corn oil, di(2-ethylhexyl) sebacate, polyethylene glycol and medicinal-grade light mineral oil.

The filter passes the test if smoke penetration (measured by a linear or logarithmic photometer or other comparable instrument) does not exceed 0.01%.

This procedure tests whether the *in situ* HEPA filters contain pinhole leaks in the filter media, in the bond between the filter media and the filter frame, or in and around the filter frame gasket and filter supports.

**Air pressure decay test of rooms**

The rate of air leakage from laboratories, animal rooms used to house large animals outside containment cages, and communal housing for poultry should not exceed 7% per minute (logarithmic measure of pressure against time) over a 20 min period at 0.5-1.0 kPa. This rate is equivalent to less than 12.5 Pa loss in 1 min at 0.5-1.0 kPa (less than 20 l/min at 1 kPa).

**Soap bubble test**

A soap bubble test can be used as an interim pre-test for ‘gas-tightness’ of ducts and plenums, provided that all joints are readily accessible.

The equipment is acceptable if there is no bubble formation at joints when ducts and plenums are pressurised with air to 1 kPa, and a liquid detergent with a low surface tension is applied to joints from a squeezable bottle or using a soft bristle brush. An alternative pre-test involves pressurising to 0.5 kPa and observing for air loss, which should not exceed 10% in 30 min.

**Gas-tight ductwork and sewage treatment systems**

All liquid effluent treatment systems, ductwork, and associated filter housings (plenum) between the inlet side of supply HEPA filter(s) and the discharge side of exhaust HEPA filter(s), should be gas-tight at a pressure of 1 kPa. Acceptance requires a leak rate of less than $1 \times 10^{-5}$ cm$^3$/sec. The test gas can be either dichlorodifluoromethane or helium. A suitable leak detector should be used with a sensitivity of $1 \times 10^{-6-7}$ cm$^3$/sec.

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**TESTS**

**Recommended testing and certification requirements for BL 3 and BL 4 Agricultural facilities**

The test equipment and acceptance criteria described below are standardised and used in locations throughout the world.

The mandatory language is used to describe the standardised tests and acceptance criteria.
The user is encouraged to adopt the standardised tests and acceptance criteria. Arbitrary modification of test procedures may invalidate the effectiveness of the certification process and may cause a hazard.

**Dioctylphthalate filter test**

The DOP test should be performed to verify that the *in situ* HEPA filters do not contain pinhole leaks in the filter media, the bond between the filter media and the filter frame, or in and around the filter frame gasket and filter supports.

**Equipment**

An aerosol photometer with a linear or logarithmic scale is required. The photometer should have a threshold sensitivity of at least $1 \times 10^{-3}$ µg/l for 0.3 µm diameter DOP particles, and a capacity for measuring a concentration of 80-120 µg/l. The air sampling rate should be at least 28 l/min.

A DOP generator of the Laskin nozzle type (2) should be used. An aerosol of DOP particles is created by flowing air through liquid DOP. The compressed air supplied to the generator should be adjusted to a pressure of 140 kPa (as measured at the entrance of the nozzle, downstream of all restrictions). The nozzles should be covered with DOP to a depth not exceeding 25 mm.

**Procedure**

Isolate and seal the filter plenum.

Place the generator so that the DOP aerosol is introduced into the filter plenum, upstream of the HEPA filter.

Switch on the photometer and calibrate in accordance with the instructions of the manufacturer.

Measure the DOP concentration upstream of the HEPA filter.

For linear readout photometers (graduated 0-100), adjust the instrument to read 100% while using at least one Laskin type nozzle per 235 l/sec of airflow or increments thereof.

For logarithmic readout photometers, adjust the upstream concentration to $1 \times 10^4$ above the concentration necessary for one scale division (using the instrument calibration curve).

With the nozzle of the probe not more than 25 mm from the surface, scan the downstream side of the HEPA filters and the perimeter of each filter pack by passing the photometer probe in slightly overlapping strokes over the entire surface of the HEPA filter. Scan the entire periphery of the filter and the junction between the filter and the filter mounting frame. Scanning should be performed at a traverse rate of not more than 50 mm/sec.

DOP penetration should not exceed 0.01% at any point measured by a linear or logarithmic photometer. Identify all points of leakage which exceed 0.01% of DOP penetration. Repair all identified leaks and repeat the test until the acceptance criteria specified above are satisfied.

**Containment room: pressure decay/soap bubble test**

This test will determine if the wall, ceiling and floor surfaces of a containment building or room used to house livestock or poultry will serve as a barrier to prevent the release of hazardous material to the environment or adjacent areas. This test can be conducted under either vacuum or pressure, as described below.
Equipment and materials

The following equipment and materials are required:

- sealing materials (wood, metal or plastic plates; pressure sensitive tape; plastic sheets; rubber stoppers) to form isolation barriers within the test zone
- source of air pressure (portable tank or compressed air) or vacuum pump with a capacity to satisfy the test criteria
- calibrated and scaled manometer (preferably inclined), pressure gauge or pressure transducer
- soap solution (e.g. liquid detergent with a low surface tension or commercial test solution)
- soft bristle brush or squeezable bottle to apply soap solution to the surface.

Procedure

Isolate and seal all external openings (e.g. doors; ventilation ducts, supply and exhaust; drains) in the room, area or system to be tested. Sealing materials should cover and seal only the opening, so that the adjacent permanent seals can also be tested.

Pressurise the room or building with air to a minimum of 0.5 kPa.

Observe and record test pressure and decay rate. Interior pressure or vacuum can be measured with an inclined manometer, pressure gauge or pressure transducer.

Survey all joints, corners and sealed penetrations within the room or building for audible leaks. Mark each leak and repair after shutting down the source of air pressure. Do not re-test until sealant or other repairs have set and cured in accordance with the instructions of the manufacturer.

Further leakage may be detected using the soap bubble test described below.

Apply soap or commercial detector solution on all joints, corners, gaskets and sealed penetrations within the room or building (or other locations which can be a point source of air leakage) and observe for bubble formation.

Establish 0.5-1.0 kPa negative pressure in the room and observe for bubble formation. Leaks will be indicated by bubbles. Leaks may occur which blow the detection fluid away from the hole without forming bubbles; these may be detected by the feel or sound of a slight airflow.

The air leak rate should not exceed 7% per minute (logarithmic measure of pressure against time) over 20 min at 0.5 kPa. Normally, this air leak rate is equivalent to 12.5 Pa pressure loss in 1 min at 0.5-1.0 kPa (less than 20 l/min at 1 kPa).

Mark each leak and shut down the source of air pressure or vacuum.

Repair all identified leaks and repeat the test until the acceptance criteria specified above are satisfied. Do not re-test until sealant or other repairs have set and cured.

Welded ductwork: pressure decay/soap bubble test

This test may be used to locate leaks in the gas-tight ductwork or sewage treatment systems before conducting the halogen or helium leak test (final test). This test avoids contamination of the surrounding area with halogenated compounds, which would interfere with halogen detection during final testing.
Equipment and supplies

The equipment and supplies specified above (see ‘Containment room’) are also applicable for testing welded ductwork.

Pressure decay/soap bubble (pre-test to gas-tight test for ductwork)

The procedure for pre-testing ductwork is basically the same as that described above for a containment room. The only exception is that the temperature inside the ductwork must be within 1°C of the ambient room temperature. This equilibration takes 20-30 min when room temperature is approximately 20°C.

All welds, gaskets, penetrations, or seals on exterior surfaces of ducts and plenums must be able to sustain air pressure for 20 min and must be free of soap bubbles at 1 kPa.

Gas-tight ductwork: helium or halogen leak test

Helium should be used as the test gas; dichlorodifluoromethane is also acceptable, however, provided that the use of halogenated compounds is legal in the country where the test is performed. As a final test, the helium or halogen leak test is performed at a pressure of 1 kPa on all welded ductwork and plenums, and liquid effluent (sewage) treatment systems. The helium or halogen will enable the examiner to determine whether exterior joints created by welding, gasketing or use of sealants are free of leaks. Any leak might release potentially hazardous materials into the work environment or the atmosphere. Access doors (for HEPA filters or dampers) in the ductwork or plenums located within the established containment boundaries should be tested and certified as part of the ductwork system.

Equipment and materials

Helium may be substituted by another gas, provided that the appropriate detection equipment is used.

In addition, the following equipment and materials are required:

- industrial type halogen leak detector capable of detecting a halogen leak of $1 \times 10^{-7}$ cm$^3$/sec, calibrated in accordance with the instructions of the manufacturer using a calibrated leak standard
- source of halogen gas
- respirator equipped with a cartridge for organic vapour removal, to be worn by person generating gas on high-pressure side
- two-way communication system
- calibrated and scaled manometer (preferably inclined), pressure gauge or pressure transducer.

Procedure

Remove halogenated compounds from the test area.

Welding and smoking are prohibited in the test area.

Calibrate the leak detector in accordance with the instructions of the manufacturer. Adjust the leak standard to indicate a leak rate of $1 \times 10^{-7}$ cm$^3$/sec.

Prior to testing, perform a background scan of the area to ensure that the atmosphere is free of halogenated compounds.
Pressurise all sealed ducts and plenums to 1 kPa with a mixture of dichlorodifluoromethane and air (at a v/v ratio of 1:9).

Move detector probe over seams, joints, gaskets and other areas of possible leakage, at a rate of approximately 25 mm/sec. Keep detector probe approximately 6-12 mm from the surface.

Leak rate should not exceed $1 \times 10^{-5}$ cm$^3$/sec.

Identify all points of halogen leakage which exceed $1 \times 10^{-5}$ cm$^3$/sec.

Repair all identified leaks and repeat the test until the acceptance criteria specified above are satisfied. Do not re-test until sealant or other repairs have set.

**GENERAL OPERATIONS**

**Personal clothing**

To enter veterinary research areas designated as BL 3 or BL 4 Agricultural containment zones, all personal clothing (including undergarments) should be removed and replaced with designated laboratory and animal clothing, provided for exclusive use within the contained space.

This special clothing should be sterilised after use, then laundered and re-used.

**CONCLUSIONS**

Among the seven countries represented at the First International Veterinary Biosafety Workshop, unanimous agreement was reached on the following points:

- Evident similarities exist between facilities, and all have similar biosafety (security) problems.
- The location of subsequent meetings will alternate among participants.
- The workshop format focusing on biosafety issues was considered very beneficial and productive, and to be occurring at an appropriate time.
- Further workshops will be held approximately every eighteen months.
- The host country will finance the preparation of workshop proceedings.
- Presenters will be individually responsible for the technical content and format of their written submissions.
- Participants will be responsible for their own travel and per diem expenses.
- Participants must have extensive knowledge of biosafety within their organisation and the institutional implementation programme.
- Each country must present information on the chosen topic for the workshop.
- Proposed topics for future meetings are as follows:
  a) classification of risk levels, with evaluation criteria, for epizootic and zoonotic disease agents (including foreign disease agents or exotic strains of endemic diseases)
  b) recommendations for immunisation practices and policies
  c) standardisation of practices and procedures for handling zoonotic agents.
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Résumé : Les auteurs font des recommandations sur les infrastructures de base, les équipements spéciaux, les installations et autres conditions de conception et de fonctionnement garantissant la sécurité microbiologique d’un local d’isolement pour animaux. Le respect de ces paramètres devrait permettre le logement et la manipulation d’animaux infectés par des agents pathogènes sans risques sanitaires. Les auteurs décrivent quelques essais de mise en service et conditions d’agrément de ces installations. Ces dispositions diminueront l’exposition du personnel aux agents infectieux, limiteront la contamination entre les animaux utilisés dans diverses expériences ainsi que la transmission entre animaux d’une même expérience, et réduiront le risque de dissémination d’agents pathogènes dans le milieu extérieur.


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Resumen: Los autores presentan recomendaciones sobre los requisitos mínimos en cuanto a infraestructura, equipamientos especiales, instalaciones y otras características funcionales y de diseño que definen un espacio de hospedaje animal microbiológicamente seguro. Se espera que estos parámetros de biohospedaje permitan alojar y manipular de forma segura el ganado y las aves infectados con agentes patógenos. Se describen los controles físicos y los requisitos administrativos necesarios para poner en funcionamiento tales
Instalaciones de esta índole minimizarán la exposición del personal a agentes infecciosos, limitarán la contaminación cruzada entre experimentos, minimizarán la transmisión horizontal entre animales utilizados para la investigación y reducirán las probabilidades de que agentes patógenos sean liberados al medio externo.


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REFERENCES


