Notes:-

1. Corridor walls are especially prone to damage due to the movement of carts, cage racks, etc. Therefore, it is usually necessary to protect the walls and corners with some form of bumper guards or protective shields. These are available in many materials, such as plastic, stainless steel and aluminum. Care should be taken when selecting bumper guards to ensure that they can be easily and thoroughly cleaned and that they cannot harbor vermin.
2. Ceilings

As with floors and walls, ceilings must be resistant to frequent washing and disinfection; however, they are not subject to the same wear and tear. The preferred substrate for ceilings is moisture resistant drywall that is well sealed at all ceiling-wall joints and penetrations. It should be coated with a two-stage epoxy finish or a high-quality enamel paint. It is easier to patch enamel if required, but overall, it is demonstrably less durable. A seamless ceiling should be provided in all animal holding and procedure rooms. It is often necessary to have access to the mechanical and electrical services which run in the space between the ceiling and the roof or the floor above. It is recommended that these services be located above hallways, rather than in animal rooms, whenever possible. A T-bar ceiling can be used to permit access to the services. The suspension framing is often subject to corrosion from high moisture levels and hence reinforced plastic, aluminum or stainless steel should be considered. The panels should be easily cleaned (smooth-surfaced vinyl-coated drywall panels work well). Lighter panels should be kept in place with clips to improve the seal between the panels and the frame. The use of the underside of concrete slabs as ceilings with no sub ceiling is not recommended; it may be difficult to clean and the exposed pipes and mechanical services tend to collect dust. These ceilings may also be subject to corrosion from high moisture levels. At a minimum, concrete must be sealed with purpose made products to prevent the continuous surface erosion and dust formation.

1. All animal holding rooms and/or their associated anterooms should have a hand washing sink, preferably located near the door. Every animal holding room should be supplied with hot and cold water and a sink, preferably stainless steel, for washing hands. The sink water controls should be automatic or wrist, foot or knee activated. The sink should be located relatively close to the door to allow hand cleaning upon entry and exit. The drains for these sinks must be sealed such that waste water cannot be aerosolized into the animal room. It is advisable to have a hose connection as well, especially in large animal holding rooms. There are good built-in hose bibs specifically designed for animal facilities (see Diagram 22).
2. Floor drains should be strategically located and designed so that they can be sealed when not in use or easily flushed to maintain an effective water trap. Floor drains are required in large animal rooms and should be a minimum of 15 cm in diameter and contain flush systems. These may be incorporated with floor trenches, depending on the method used for housing the larger animals. Floor drains are not required in rodent holding rooms, although they may be useful during major clean-ups between groups of animals. If floor drains are used in the rodent rooms or in corridors, they should be a minimum of 10 cm in diameter and incorporate running traps with cold water primer lines or a manual (see Diagram 23) or automatic flushing system. All floor drains should be designed to prevent backflow. All floors should slope towards the drain. Where floors are flat (e.g., in rodent rooms to keep the racks level), the area surrounding the floor drain should be dished to facilitate the capture of water moved toward.
3. All electrical outlets in animal rooms and in other areas where they may be exposed to water must have a ground fault interrupter (GFI) and be fitted with an all weather cover.
4. All light fixtures throughout the animal facility should be vapor-proof. All light fixtures in animal rooms, cagewash area, surgical suite and other areas that may be exposed to water or high humidity must be vapor-proof. It is recommended that all other light fixtures in the facility be vapor-proof as well to facilitate cleaning.
5. HVAC systems in laboratory animal facilities must operate continuously 24 hours per day, year round.
6. The waste storage area should provide adequate storage for animal excrement, soiled bedding and waste feed, and should be designed to facilitate its sanitation. The ventilation for this area should be segregated from the rest of the building or at least designed so that there is no possibility of air leaking from this area into other parts of the building or other buildings. If the waste is not removed on a daily basis, then consideration should be given to cooling the waste storage room. The disposal of soiled animal bedding and the remains of dead animals can be handled in a number of ways, depending on local codes, availability of acceptable waste elimination equipment, and the presence or absence of biohazardous agents and toxic substances in the discarded material. There are two principal methods of maximally effective and safe elimination systems: incineration, and alkaline hydrolysis or digestion.
7. The cage wash area must have adequate ventilation to maintain a safe environment conducive to human physical activity and to prevent the spread of vapor and contaminants. The differential pressure on the dirty side of the cage wash area must be strongly negative to all surrounding areas.
8. Doors in animal facilities must be capable of taking considerable abuse. Top quality products and workmanship should be used. The doors and frames should be made of a durable metal and be completely sealed or filled with foam to prevent access to vermin such as cockroaches. The frames should fit within the wall space, rather than overlapping, so that there are no ledges to collect dust. The doors should be large enough to accommodate the movement of all required materials, such as cage racks. The minimum sizes are 120 cm nominal opening for a single door and 180 cm nominal opening for a double door. In order to protect the doors from damage, it is often necessary to cover at least the lower half with sheet stainless steel, aluminum or plastic. Bumper guardrails may also be required on more vulnerable doors. A door sweep should be installed on the base of the door if the clearance exceeds 3.2 mm. Windows in the doors are extremely useful to allow observation into rooms and as a safety feature. The windows on animal holding room doors do not have to be large (e.g., 15 x 20 cm). It is necessary to be able to close the window to external light or movement as required; however, if a screening device is incorporated into the door structure, it should be well sealed so that it does not harbor vermin. Opaque magnetic sheets can be used effectively to occlude small windows on animal holding room doors. Larger windows in doors have also been used successfully. Where animal rooms or procedure rooms are small, they help make the space less claustrophobic. Larger windows can be temporarily blocked out with caulked plastic laminate when necessary.
9. An emergency power source must be available for all facilities holding animals for research, teaching and testing purposes. In order to maintain the health and well-being of animals during power outages, it is essential that critical functions be supplied with emergency power. A reduction of 50% of the air supply for short periods of time may be acceptable; however, the maintenance of air pressure differentials is essential, especially in containment areas. Sufficient emergency lighting should be available to permit personnel to function safely in the animal facility. The surgical suite should be supplied with sufficient power to allow the completion of surgeries during a power outage. All equipment requiring electricity that could be in use during a surgical procedure must be on the emergency power supply. This includes such items as a portable X-ray unit, as well as the basic equipment, lamps, respirators and electrocauterizers. Emergency power may also be required to maintain the security system. The most common source of backup power is a diesel-powered electrical generator. The fuel holding tanks should be capable of holding enough fuel to run the generator for a minimum of 24 hours. Generators powered by natural gas are also used, but are dependent on a constant gas supply and are therefore less independent than diesel-powered generators. Propane is a gas alternative that can be stored. Electrical generators are very noisy and require careful positioning with sound and vibration isolation relative to the animal facility.
10. Temperature, relative humidity and differential pressures should be monitored frequently in each and every animal holding room. The animal environment must be monitored. This can be done with stand-alone devices that record the temperature and humidity; these systems usually require the manual recording of the temperature and humidity on a daily basis. Computer systems have been developed that will monitor more environmental parameters on a more frequent basis and send the information to a central location. For example, temperature, humidity, air exchanges, air pressure and lighting can be recorded for each room in a facility throughout the day. Alarm systems can be built in which will signal if the environment fluctuates outside set parameters. The alarms can also be transmitted by phone lines to remote locations. The environmental monitoring can be tied in with the security system. Temperature should be monitored and recorded at approximately 90 cm from the floor. Temperature sensors for activation of reheat coils are commonly located in the exhaust duct close to the animal room. This, in effect, reads the sum total of the temperature of the supply air plus heat gain in the room. Humidity can be recorded in the supply air duct. Permanently fixed air pressure recording devices are becoming more common in animal facilities. Regardless of whether they are builtin recording devices or not, the differential air pressures within the animal facility should be checked on a regular basis to ensure the correct direction of airflow. This is extremely important for barrier units. Differential pressures should be recorded between animal holding rooms and the adjoining rooms or corridor. It may be more practical and effective to measure the actual direction of movement of air between areas than to measure differential pressures.
11. All required safety equipment must be installed so that it meets safety regulations but does not compromise the functionality of the laboratory animal facility. Equipment such as fire extinguishers and fire hoses should be strategically located so that they are not bumped by equipment being moved through the facility. Hoses may be mounted in wall recesses. Fire alarms should be mounted so they will not be set off accidentally. Light alarms may be acceptable in some locations (see Section 12.1 Sound). Emergency showers and eyewash stations should be strategically located, but positioned such that they do not impede normal traffic flows. Units are available that fold up or fit into wall recesses. Sprinkler systems must be installed in animal facilities. The sprinkler systems should be designed so that they are easy to sanitize and do not harbor vermin.
12. Three aspects of light in animal facilities need to be considered: photo-intensity, photoperiod, and quality or spectral composition. These should be considered from the perspectives of both the well-being of the animals and personnel.

Photo-intensity

In most animal rooms, and especially in rodent rooms, lighting should be designed to provide at least two levels of intensity during the light cycle. For most animals, with the notable exceptions of diurnal sight-oriented mammals (e.g., greyhounds), low light levels do not present a problem. Bright light, however, should be avoided. Animals with non-pigmented irises, such as albino rats and mice and white pinkeyed rabbits, are not able to accommodate to more intense light levels. It has been demonstrated that light levels above 325 lux (30 foot candles) for prolonged periods will induce irreversible and progressive phototoxic retinopathy in albino rats. Ophthalmological and histopathological changes observed in the retina that are phototoxically induced are indistinguishable from degenerative changes induced by chemical toxicity or hereditary anomalies (Bellhorn, 1980). For animal rooms that are to house common species of laboratory animals, the normal light intensity should be approximately 325 lux at one metre above floor level (Bellhorn, 1980). Where task lighting for people is needed in the animal room, it should be restricted in its dispersion throughout the room, if possible. Furthermore, the period of substantially-increased light levels should be minimized. Levels of around 1000 lux (90 foot candles) provide adequate task lighting if used judiciously. An override control will permit increasing the intensity up to a maximum of 1000 lux for limited periods of time. The intensity should automatically go back to the lower level after a set period of time (commonly 20 minutes). Measuring photo-intensity in the centre of an animal room is fraught with problems because it does not take into account the overall light distribution throughout the room, nor does it address the position and distribution of the cages relative to the light source. The latter should be considered in planning the positioning of light fixtures if rack and cage deployment is at all predictable. The light intensity on the top shelf of a rack may be considerably higher than that within shelves of the rack, and hence one should avoid placing cages on the top shelf.

Photoperiod

Diurnal light cycles in animal holding rooms should be controlled and monitored centrally. The intensity of light required for humans to carry out their daily activities in an animal room is often too bright for the animals held within and may cause retinal damage. Therefore, it is recommended that the lights be designed so they can be set at different intensities, especially in rodent rooms and for some avian species (see Section C.12.2.3 Spectral quality, for more information on light sources). These lights should be on automatic controls that revert the lights back to the preferred intensity for the animal occupants after a specified time lapse (e.g., 20 minutes). Where the mechanical services are located in the interstitial space, it is often possible to have external access to the light fixtures. Diagram 24 illustrates the mounting of a light fixture for external access. Rats and mice are reported to reproduce optimally and show no behavior problems using a diurnal cycle of 14 hours light and 10 hours dark. Most species held for maintenance do well on a 12:12 light cycle. Animals' endogenous rhythms can be significantly skewed if the dark phase of the cycle is interrupted. Therefore, it is recommended that windows to animal holding rooms be occludable. Window closures can be built into the door or opaque magnetic covers can be used. Nocturnal animals are more active during the dark hours and may not respond well to handling during daylight hours when they are resting. Reversed light cycles are useful when working with hamsters, marmosets, etc., and in some cases with mice and rats. It has been shown that the length of 'day' (light) and 'night' (dark) in rodents influences: a) hepatic metabolism of drugs; b) pentobarbital sleep time; c) DNA synthesis and mitoses; d) serum cortisone levels; e) serum lipids; and f) body temperature. Therefore, consistency in the diurnal cycle is often critical to reliable research results. In certain circumstances, an abrupt change between light and darkness is not acceptable, and the crepuscular periods of dawn and dusk must be simulated.

Spectral quality

The wavelength of light should simulate the natural wavelengths of sunlight as closely as possible. Most animals do best at light wavelengths similar to that of natural sunlight, ranging from 300 nm to 2000 nm with the majority clustered between 450 nm and 700 nm. The human visible spectrum is between 390 nm and 750 nm. Lighting, and particularly its spectral quality, plays a profound role in the demeanor and work performance of users. Plastic cages used to house most rodents may actually alter the wavelength and intensity of light the animals receive, especially if the cages are equipped with filter caps.

Incandescent light source

Incandescent light emitted from a standard light bulb with a glowing filament has an emphasis on red or longer wavelengths of the visible spectrum. Although not ideal, this will provide adequate illumination.

Fluorescent light source

Fluorescent light, emitted by electricallycharged ionized vapor, approaches sunlight more closely than incandescent light with increased emphasis on the violet or shorter wavelengths of the visible spectrum. Biologically-balanced fluorescent lighting is now available that contains wavelengths in the ultraviolet range. Both rats and hamsters have been shown to do better under these wide spectrum lights, and therefore, biologically-balanced lights are recommended when using fluorescent fixtures. The level of illumination in fluorescent lights deteriorates with the life of the tubes. It may therefore be necessary to install lighting at the higher end of the threshold and allow it to deteriorate to the lower range. However, the appropriateness of this approach will depend upon the type of investigation taking place. For example, where 325 lux is required at one metre high at room centre, initial levels at installation may have to be closer to 400 lux, which is unacceptable, particularly for albino rats. A possible solution is a more frequent change of lower intensity tubes or the use of a diffuser.

Light emitting diodes

Recent work has demonstrated that light emitting diode (LED) illumination compares favorably in its biological effects with the more common sources of lighting previously mentioned. It has been deemed safe for use with laboratory rats (Heeke et al., 1999). Since the rat has been regarded as the most susceptible laboratory animal to phototoxic retinopathy, this provides a good indication of the element of safety at levels of illumination equivalent to other sources (Heeke et al., 1999). The advantages of light emitting diodes are that they: are inexpensive to install and maintain (energy efficient); are solid state; have a long life; have a wide range of spectral control; produce low heat; and have a mechanical size advantage.

Light tubes

In order to achieve an even distribution of light in animal rooms, the location and spacing of the light fixtures is a critical component of planning and design. More precisely, the points of origin of the light need to be spatially arranged and laid out in the 'reflected ceiling plan'. In many cases, this requires access into the animal room to change tubes or bulbs in the fixtures. It is possible to avoid this where interstitial space exists, so that the actual light source can be positioned above an integral transparent panel in the ceiling and be accessible from above. Light tubes are a new alternative to provide even light distribution in spaces such as animal rooms, where the actual source of light can be positioned outside the space, facilitating servicing by plant maintenance staff. The source is at one end of a tube that is designed to distribute even illumination along its length. The technology permits high inaccessible spaces (e.g., large atria) to be evenly illuminated from easily accessed light emitting sources. The units can be used horizontally or vertically. Currently, the lamps used are metal halide, and these generate significant levels of heat as well as light. However, LED sources may be integrated in the future, which will render the system very adaptable and economical to operate. The technology offers significant advantages in illuminating restricted access areas, such as biocontainment suites, and also in renovating areas with very limited floor-to-floor distances.

1. Heating, ventilation and air conditioning (HVAC)

The HVAC system should supply clean air at specific temperatures and humidity to the animals housed within a room and exhaust all contaminated air. It is common to try to control environmental parameters at the room level (macroenvironment); however, the real concern should be at the cage level (microenvironment) where the animal is housed. The movement, and hence quality, of air in the microenvironment will be affected by such things as distribution of air in the room, location of the cage within the room, cage design, rack or shelf conformation, species held, bedding type, use of biosafety cabinets, equipment, motors, etc.

HVAC systems in laboratory animal facilities must operate continuously 24 hours per day, year round.

Because so much in the animal facility depends upon the continuous operation of the HVAC system, adequate redundancy is critical (see Section 13. Redundancy). Adequate redundancy may vary considerably depending on the requirements of specific zones within the animal facility. Generally, all conventional animal holding space should be supplied with at least 50% of its normal air turnover during short cutback periods of less than 12 hours. It is critical that differential pressures be maintained for inclusion and exclusion zones. Duplication of fans and an alternative electrical power source to maintain operation of the balanced system to an appropriate level is mandatory. Containment facilities will require exhaust fan redundancy (see AAFC, Containment Standards for Veterinary Facilities, http://www.inspection.gc.ca/ english/sci/lab/convet/convete.shtml). The HVAC systems for animal research facilities are therefore very expensive and may comprise 40% or more of the total construction costs.

1. Temperature for cold countries

The temperature of each animal room should be controllable within ±1°C. The most common method of controlling temperature is by bringing cooler air to the room level (i.e. 12 to 14°C). The air for each individual room is brought to the preselected temperature by means of a reheat coil immediately before it is distributed to the room. The reheat system is controlled by monitoring the temperature of the air as it leaves the room, which constitutes the sum total of the heat of the air supplied plus heat gain in the room from animals and equipment motors (e.g., fan motors on ventilated racks and in biosafety cabinets). It is important to note that reheat coils supplied from manufacturers are set to fail 'on'; however, in animal facilities they must be set to fail in the 'off' position. Windows to the exterior make temperature control difficult. Severe cold exterior temperatures in winter and warm summer weather create temperature gradients within spaces due to conduction and convection that are difficult, if not impossible, to deal with evenly throughout the room. In addition, animals in the room may absorb or lose considerable amounts of heat by radiation, depending on their location relative to the window. Therefore, windows are generally not incorporated into animal holding rooms. The type of caging and bedding will also affect the animal's ability to influence its own environment. For example, animals in stain less steel cages with non-contact bedding will usually require room temperatures several degrees higher than those in plastic cages with contact bedding, due to differences in insulation and air movement within the cage.

1. Relative humidity

Relative humidity should be maintained between 40% and 60%, depending on the species, and controlled to ± 5%. The relative humidity may be controlled at the suite level, rather than on a room-to-room basis. Most animals do well at 40 to 60% relative humidity, but not less than 35% or greater than 70%. The relative humidity should be kept consistent (± 5%). In Canada, building humidity may cause moisture problems and damage to the building structure due to condensation on colder external walls in the winter months. Therefore, animal housing facilities must be extremely well insulated and/or all animal holding rooms may be located in the core of the facility, surrounded by a corridor or service areas with one outside wall and lower humidity levels.

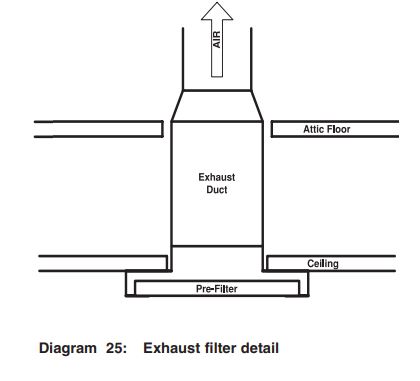
1. Fresh air

Animal facilities should be supplied with 100% fresh air. Air should not be recirculated within the facility. Good quality air should be available to all animals at all times. The facility fresh air intake. should be located to ensure that exhaust air from the facility or from adjacent buildings is not drawn back into the facility. It is strongly recommended that the positioning of the fresh air intake and its relative position to the facility exhaust and surrounding structures be subjected to fluid dynamic studies. In some cases, sufficient information may be obtained from computational fluid dynamics. However, in other projects it may be necessary to have wind tunnel tests performed on topographical scale models of the site with the facility proposed air intakes and exhausts in different locations and the surrounding buildings located accordingly. The costs of these studies relative to the overall design and construction costs is small, and their contribution to effective and safe function in all meteorological conditions far outweighs the expense. Each building has a cloak of air, known as the building envelope, that interfaces physically with the structure to the extent that it does not follow the movement patterns of air further away from the building. Contaminants released into this building envelope may migrate to other points on the surface of the building, for example, an office window, a door, or the air intake for the animal facility. Fluid dynamic studies will guide good design features to minimize contaminant intake. All fresh air is filtered into the facility to remove larger particulates. Where the quality of the air is as 'fresh' as is available but not consistently clean enough due to pollutants, it may be necessary to use more sophisticated filters such as charcoal and HEPA filters. The quality of air in high-density urban areas should be evaluated and appropriate systems should be incorporated. For economical and environmental reasons, it is best to reclaim as much energy as possible from the relatively large volumes of exhaust air vented from the facility. A system of heat reclamation compatible with the overall design of the HVAC system is recommended.

1. Air exhaust

Air must be exhausted efficiently so that the contaminants in the facility environment do not accumulate beyond acceptable levels. Exhaust ducts should be fitted with filters at the room level to reduce the accumulation of particulate matter in the duct. All exhaust ducts should be tightly sealed. Animals contribute carbon dioxide, moisture, ammonia (from urea) and allergens to the air. This contaminated air must be efficiently removed from the room so that it does not accumulate in the microenvironment of the animal cage. The air exhaust system should be designed with easily changeable filters (30% pleated) on every exhaust grille within each room to remove all gross particulate matter, such as animal dander, bedding dust, etc. (see Diagram 25). In rooms designed to quarantine animals or contain biohazards, more efficient filters should be used, such as HEPA filters. The exhaust system should be tightly sealed to eliminate the potential for contaminating other areas. The external building exhausts should be located so that air exhausted will not enter other intakes. A local air distribution study at the build

The rate of air exchange within a room must be such that clean, fresh air is available to all animals and personnel at all times. For conventional animal holding rooms, the HVAC system should be capable of supplying and exhausting 15 to 20 air exchanges per hour. In order to maintain potential air contaminants below acceptable levels, it is recommended that there be 15 to 20 air exchanges per hour in a room. This recommendation, however, does not take into consideration the efficiency of air distribution, the number of animals held or how they are being held. While this recommendation may be effective for large numbers of animals housed in conventional caging with less than ideal air distribution (most systems), the requirement may be considerably higher for animals housed in static filter top cage units or less in rooms where animals are housed in ventilated cage units. Ideally, HVAC systems should be designed so that the number of air exchanges

1. Differential pressure
2. **
3. Differential pressure

Differential pressures can be used to create an air barrier between two areas or zones of a facility. Differential pressures between areas of an animal facility should be set so that air flows from the cleaner areas of the animal facility to the dirtier or potentially contaminated areas. Differential pressures between rooms and corridors are used to control the movement of air and eliminate a potential source of cross-contamination. Generally, clean areas are kept at a positive pressure relative to dirty areas (i.e. clean animals, clean side of cage washer, food and bedding storage, surgery, etc. should be at a higher relative pressure than dirty animals, quarantine, necropsy, dirty side of cage washer, waste storage, etc.). Those areas needing to be kept clean (exclusion), such as holding rooms for specific pathogen-free (SPF) animals, should be under positive pressure; whereas, those areas where air movement outwards needs to be limited (inclusion), such as biohazard areas, should be negative. Where greater control of pressure differentials is desirable, anterooms are effective. They create an air barrier between the holding room and the corridor. It is common to set differential pressures in suites for exclusion to have a cascade effect, such that the air pressure decreases as one goes from the holding room to the anteroom, to the corridor, and then to the outside of the suite (see Diagram 26). The reverse cascade effect is often used for inclusion, such that the holding room is the most negative. The cascade system of differential pressures assumes that specific animals are clean or dirty and will always remain that way. In actual fact, many disease research experiments require the use of clean animals that are intentionally infected with disease organisms, and there is also the possibility of clean animals becoming infected unintentionally. Therefore, in many cases, it is beneficial to consider a system that offers both inclusion and exclusion at the same time. Such a system may be established by supplying clean air to an anteroom at a pressure greater than that of both the holding room and the corridor (see Diagram 27). With proper management, the positive pressure anteroom should provide an effective way of establishing an exclusion barrier, an inclusion barrier and a combined inclusion/exclusion barrier. In order to maintain differential pressures, doors must be closed and the time that the doors remain open should be minimized. In order for anterooms to be effective barriers, only one door of an anteroom should be opened at a time; otherwise both differential pressures are eliminated, thus destroying a major function of the anteroom. It is essential.

1. All animal facilities must have an emergency electrical supply capable of maintaining at least some of the functions of the HVAC system and essential services. The maintenance of air pressure differentials is essential, especially in inclusion or exclusion situations, in order to contain a biohazardous risk and protect extremely valuable animal research stock from contamination. Critical areas should be identified and HVAC systems built accordingly, with appropriate controls and monitoring systems. Fresh air at the appropriate temperature must be available 24 hours per day, year round. The animal facility should be divided-up into various functional areas and separate HVAC systems designed for each. For example, separate HVAC systems could supply the animal rooms, the surgical suite, personnel areas and each biocontainment area. There should be more than one supply and exhaust fan to all of the above areas, with the possible exception of areas for human occupancy. The total maximum capacity required for each area may be divided by the number of supply and exhaust fans to be installed. Ideally, if two complementary fans are to be installed, each should be capable of supplying 100% of the total required capacity during an outage of the other fan. Normally, the fans should be used at 50% of their total capacity, with the anticipation that outage times will be less than 12 hours. The supply and exhaust fans should also be sized and controlled so that differential pressures between critical areas are maintained during the failure of a fan. In containment facilities, an exhaust fan must be functional and capable of maintaining the containment facility at a negative differential pressure at all times (AAFC, Containment Standards for Veterinary Facilities, http://www.inspection.gc.ca/english/sci/ lab/convet/convete.shtml). Backup chillers and heat exchangers should also be installed. It is recommended that they be individually sized to meet maximum requirements independently, and then that they each be run at 50% capacity. This will allow one unit to meet all requirements while the other is being repaired or maintained. An example of a dual parallel HVAC system is given in Diagram 35. Generator capacity to operate the animal facility at normal levels during grid failures is recommended. If this is not possible, then power must be available to maintain the HVAC system, emergency lighting and other critical equipment, such as surgical lights and life monitors. Continuous operation without compromising the health and welfare of the animals is fundamental to the commitment to the best principles of animal care and the protection of the research programs