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THE ECOLIBRIUM ANNUAL AIRAH AWARDS SPECIAL

One with the lot

Quarantine facilities use serious kit . . . just like this.

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COVER FEATURE

The diversity of fauna and flora species to be accommodated required an equally diverse range of buildings and mechanical services solutions to meet design conditions, provide an appropriate level of redundancy, address energy efficiency and most importantly address the strict requirements for containment.
Images supplied by A.G. Coombs.

All creatures great and small

In seeking to consolidate all post-entry quarantine facilities into a single location, a site near Melbourne's international airport has been selected for Australia's flagship quarantine control facility. It will become the first point of entry for imported animals – small and large – plant material and insects entering the country. **Sean McGowan** reports.

For many decades, the Department of Agriculture and Water Resources (DAWR) has operated five Post-Entry Quarantine (PEQ) facilities around Australia – Byford in Western Australia, Spotswood and Knoxfield in Victoria, Eastern Creek in New South Wales, and Torrens Island in South Australia.

As part of the nation's biosecurity continuum, these facilities have worked

> Each type of import – be it cat, dog, horse, plant or bee – required a purpose-built, uniquely designed building in which to house them

in conjunction with pre-import requirements and at-border management to safeguard Australia from harmful pests and diseases being brought into the country.

But with leases on these properties having expired, or due to expire by the end of 2018, the department has taken this opportunity to plan for Australia's long-term post-entry quarantine needs. It's done this by building a new, purpose-built PEQ facility on a Commonwealth-owned parcel of land in Mickleham in Melbourne's north.

This new facility consolidates all existing facilities into one location.

With the first stage at Mickleham operational for over a year, the second and final phase of construction is now almost complete.

It will become the first point of entry for imported animals (small and large), plant material and insects entering the country. The facility provides secure accommodation and biological containment until the quarantine period has ended.

The diversity of fauna and flora species to be accommodated on one single site has required an equally diverse range of buildings and mechanical services solutions to meet design conditions (both comfort and critical), provide an appropriate level of redundancy, address energy efficiency and meet budget constraints.

"Most importantly, however, was the underlying requirement for containment," says Jacobs senior design manager, Jim Hargreaves, Assoc.AIRAH.

Jacobs was invited to respond to a Request for Tender in late 2011, with the design consultants' specialisation in scientific and biocontainment facilities making it a good fit for the project.

At the end of the schematic design stage, Jacobs was joined on the project by builder CPB Contractors. Mechanical services specialist contractor, A.G. Coombs joined the project at construction stage.

The most complex and demanding building on the site is the Avian facility, it includes five high criticality Bio Containment Level 3 units.

The project commenced in early 2012, with about two years of design and planning following. This included site selection and liaison with local stakeholders.

Due to its immense scale, a staged approach was also taken.

According to Hargreaves, the Department had a clear vision for its new facility, and therefore provided a very detailed design brief.

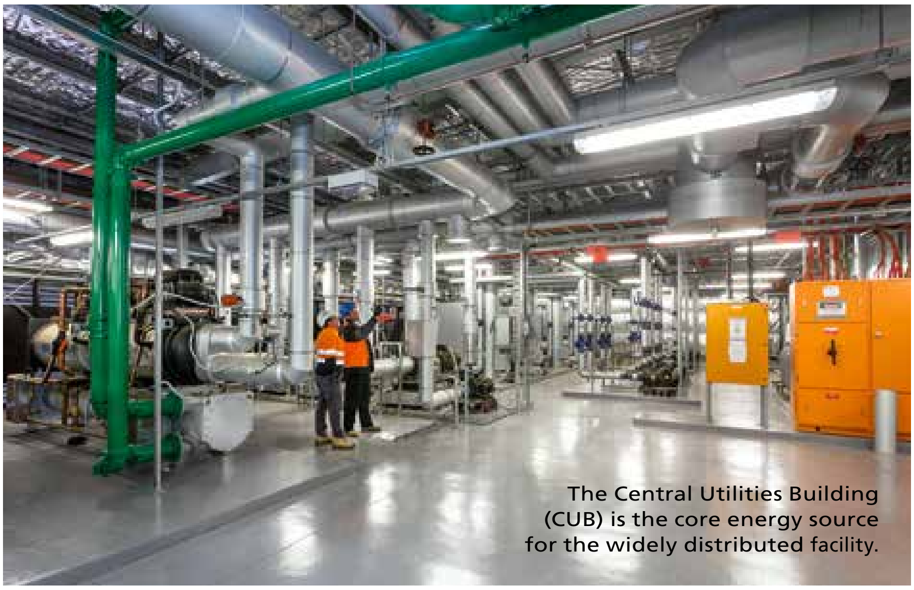
Each type of import – be it cat, dog, horse, plant or bee – required a purpose-built, uniquely designed building in which to house them. Ultimately, 14 individual buildings have been constructed on the 144 hectare site.

"There were many prescriptive and performance-based requirements within the functional design brief, some of which included the type of HVAC systems to be used, minimum air-change rates, minimum ventilation rates and individual HVAC zoning for specific spaces," Hargreaves says.

Given the nature of the PEQ facility, biocontainment is of utmost importance.

In an evolving process of intensive workshops attended by Jacobs, the DAWR, project managers and various stakeholders, the functional design brief of each building was amended and refined to include additional advice, experience and recommendations from the design team.

This led to the inclusion of a Central Utilities Building (CUB) as the core



The Central Utilities Building (CUB) is the core energy source for the widely distributed facility.

energy source of the widely distributed facility. The recommendation was based on risk assessment, failure analysis, whole-of-life assessment and external peer review.

The CUB comprises four high-efficiency condensing boilers with a total installed capacity of 3.4MW, as well as four high-efficiency magnetic bearing chillers with a total installed capacity of 5.3MW.

> All infrastructure in the CUB is provided in an N+1 configuration

Heat rejection is achieved via three cooling towers with a total installed heat-rejection capacity of 6.9MW.

The CUB also houses air compressors and emergency-power dual-fuel generators.

All infrastructure in the CUB is provided in an N+1 configuration.

Many of the CUB's services are reticulated around the site on a critical services link (CSL).

Approximately 3,140m² of Bio Containment Level 2 greenhouse space has been constructed.

Requiring staged construction, the design of the infrastructure and reticulated systems needed to allow for progressive commissioning and balancing.

Each compound (building) around the site incorporates dedicated plant areas for air-handling equipment and other air-side equipment.

BIOSECURITY

Given the nature of the PEQ facility at Mickleham, biocontainment – the containment of microorganisms and the prevention of their release outside the defined containment areas – is of utmost importance.

Although biocontainment levels are defined by AS/NZS 2243.3, additional requirements were set out by DAWR for quarantine containment.

The greenhouses are BC2 (Biosecurity Containment level 2) classified, while the plants laboratory building contains a BC3 space. The avian building is almost entirely BC3 classified. Other facilities on the site are not specifically biosecurity containment rated, but achieve their quarantine containment requirements by passive means, such as restricting human contact and/or contact with other animals by virtue of the separation between buildings.

Key HVAC requirements of BC2 areas included net-inward flow; no recirculation of air into areas outside the BC2 facility; regulatory-compliant fine insect mesh on all ventilation openings; and smooth, impervious and easily cleanable surfaces to rooms and associated ductwork.

"With the containment units designed for zero leakage, all ductwork on the room side of the gas-tight dampers and services penetrations connected to the rooms had to be fully sealed," says project engineer for A.G. Coombs, Emily McKernan, Assoc.AIRAH.

"This meant penetrations had to be carefully coordinated and agreed between all trades early."

The exhaust systems are sized to accommodate the inward air leakage through door seals at the nominal design room pressure. Where variable-speed fume cupboards are provided, supply air and other exhaust-air flow rates are modulated to maintain the pressure balance.

Hargreaves says there are obvious differences between the HVAC systems serving BC3 facilities and standard HVAC systems. The latter have features associated with the safe and effective gaseous decontamination of the space and its associated ductwork.

"The BC3 facilities are designed for use with a variety of gaseous decontaminants including formaldehyde, vaporised hydrogen peroxide and chlorine dioxide," he says. "Each type of decontaminant has varying methods of application and neutralisation, with respect to both the physical installation and control of the systems."

Consequently, the fumigable sections of ductwork serving the BC3 spaces have been manufactured from fully welded stainless-steel duct to provide a gas-tight system tested to zero leakage at 1000Pa. Gas-tight dampers are used to seal off the fumigable ductwork for the remainder of the systems.

BC3 spaces are sealed to allow no more than 2.0L/s leakage when pressurised to 200Pa. Doors incorporate inflatable pneumatic seals to ensure doorways are also maintained gas tight.

Active exhaust air-flow control is provided to maintain a minimum of -25Pa between the BC3 space and its airlock, and is progressively more negative towards the "dirtiest" areas, which operate at -90Pa. In addition to electronic control systems, mechanical relief mechanisms are provided to prevent an "under/over situation" that can result in catastrophic failure of the room fabric.

The control systems developed for the fumigation of the BC3 spaces manage the whole process from beginning to end. Users are provided with step-by-step instructions based on the type of gaseous decontaminant being used, via a user-friendly touchscreen.

A portable chlorine dioxide fumigation generator supplied from the US was included in the mechanical package.

Ductwork in recirculating systems and exhaust systems is fully rigid, with internal acoustic lining sealed under an impervious membrane. The room fabric of BC3 areas is extremely well sealed in order to achieve the maximum allowable leakage requirements.

All air registers contain regulator-compliant fine mesh insect screens, with those on return air and exhaust-air systems preceded by panel filters.

SPECIES SPECIFIC

Such is the function of the PEQ facility at Mickleham that each animal type has its own, uniquely designed building, with corresponding building services, in which it is housed.

The dog (total of 400 kennels) and cat (total of 240 pens) buildings utilise similar HVAC strategies, with a negative pressure maintained to minimise cross-contamination between animal rooms.

Each kennel or pen features mechanical extraction and a purpose-built door grille, while in-slab heating (utilising heating hot water from the CUB) was deemed to provide the most efficient means of keeping animals comfortable while reducing drying time after wash-downs.

Within the corridors of both buildings, HCV (heating, cooling, ventilation) units – essentially evaporative cooling with integrated gas-fired heaters – supply tempered air during winter and provide cooling in summer. The large amounts

> "The large amounts of fresh air delivered by the HCV units allow the corridors to maintain a relative positive pressure"

of fresh air delivered by the HCV units allow the corridors to maintain a relative positive pressure, thereby minimising animal odours within the human working space.

Elsewhere on the site, two completely separate equine compounds (each at least 100m away from the nearest building) feature 40 naturally ventilated

Energy-saving initiatives have been implemented in the greenhouse facilities including VAV air flow, depending on loads, economy cycles and automated sunshades.

LESSONS FROM THE CONSULTANT

Jacobs senior design manager Jim Hargreaves, Assoc.AIRAH, offers some advice when designing containment facilities.

1. **Budget**

   Containment facilities are complex and, as a result, tend to be expensive. There are regulatory requirements that must be met and in most cases are not negotiable. Do not underestimate the cost of controls and commissioning, and make allowance for rigorous testing of the systems following commissioning.

2. **Time**

   It is critical that there is adequate time for proper and thorough commissioning and testing of the containment systems. This can take months – not days or even weeks.

   Without proper testing the client is left with a system that could be unreliable and may result in loss of containment.

3. **Quality**

   If you want to de-risk a complex project, then you need to engage suitably experienced consulting engineers and contractors.

stables. Given the remote location of these compounds, office and administration areas are served by split-type direct expansion (DX) systems ranging from fan coil units (FCUs) to cassette units.

The site's Administration, Dispatch and Receivable buildings are conditioned by traditional means – air-handling systems utilising variable air volume with demand- control ventilation for the former, and split-type direct expansion (DX) systems for the latter due to its remote location.

BIRDS AND BEES

The Bees facility features a grafting room that utilises an ultrasonic humidifier to provide the higher humidity conditions necessary for the grafting of bee larvae – the process that sees worker bee larvae transferred and reared into queen bees.

But by far the most complex and demanding building on the site is the Avian facility.

Some 2,250m² in size, it includes five high containment BC3 units that will house imported birds ranging from pigeons to chickens, ducks and turkeys in strict quarantine until serology testing has confirmed they are free of disease.

"Even though we had previously successfully completed many of these high containment facilities, the avian facility was particularly challenging due to the level of redundancy of plant and fuel sources, the increase seismic design constraints to Importance Level 4, and the need to make the facility safe after a natural disaster," says Hargreaves.

Additionally, single points of failure had to be eliminated as far as practicable.

"The design of this type of facility requires an experienced team, including designers, mechanical contractors and controls contractors. A weak link in this team can be a recipe for disaster, and even the smallest alteration to these types of HVAC systems can be very costly."

The four-storey Avian facility features three levels of HVAC plant to serve one laboratory level.

All greenhouses are provided with fogging units to provide some humidity control, while adiabatic cooling is provided as back-up in the event of HVAC failure.

To improve maintenance access and minimise the lengths of stainless steel ductwork within the facility, A.G. Coombs rearranged the Avian plantroom layout within the constraints set out in the design.

"All air-handling plant serving a containment unit must only reside directly over that unit," adds Hargeaves. "Additionally, ductwork was 'banded' with colour-coding to match the colour scheme of the respective containment unit, and the floors of the plant room painted accordingly. This would provide clear visual clarity to maintenance staff of the systems and the areas they serve."

Air-handling systems serving the avian facility are all constant-volume systems, with full outside air. Run-around coils are incorporated into the air handling systems to reclaim heat from the exhaust air stream.

The steam generated in here is used only for this facility, and is distributed to steam humidifiers within air handling systems, autoclaves and the custom-designed liquid waste decontamination system (LWDS) located in the basement plant room.

The liquid waste is collected in a 12,500L collection vessel, which is then sent to a treatment vessel in batches of approximately 1,000L where it is heated to 121°C and held for a minimum duration of 20 minutes. On completion of each batch, the decontaminated waste water is cooled and sent to sewer.

Compressed air is reticulated from the CUB via the critical services link. It serves pneumatic door seals, autoclaves, air-driven actuators, the LWDS and client equipment such as incubators.

"All plant in this building has 100 per cent redundancy," says Hargreaves, "as well as an alternative fuel source."

Each containment unit is autonomous, gas-tight, and completely separated from the adjacent containment unit to avoid cross-contamination.

FLORA

As well as animals, the PEQ facility accommodates plants of various species that are being imported into Australia.

Approximately 3,140m² of BC2 greenhouse space has been constructed. Around 50 per cent is served by HCV units given that relatively wider internal temperature ranges were permissible.

LESSONS FROM THE CONTRACTOR

A.G. Coombs' project engineer Emily McKernan, Assoc.AIRAH, offers some of the key lessons learned from the PEQ facility project.

1. Detailed coordination of all services that serve containment spaces together with an assessment of their suitability for the BC3 environment is critical.
2. Upfront review of the Operational Verification procedures allows for discussions around client expectations and any envisaged limitations of the proposed systems and their design, ensuring any issues are dealt with early and the commissioning requirements are clear.
3. It is important for all parties to understand the capabilities and interfaces of typical items of equipment.
4. The commissioning of BC3 systems requires a significant amount of tuning. Having the appropriate time and funds available together with the support of your specialist contractors is needed to ensure a successful project outcome.

The remaining greenhouses are provided with full air conditioning to provide for closer internal condition control.

Several energy-saving initiatives have been implemented in the greenhouse facilities. These include VAV air flow, depending on loads (for both HCV and AHU systems), economy cycles and automated sunshades.

All greenhouses are provided with fogging units to provide some humidity control, while adiabatic cooling is provided as back-up in the event of HVAC failure, along with automated relief air devices. Directional air flow is also provided throughout.

In addition to the greenhouses, the site features approximately 1,240m² of shade house space. The shade houses are naturally ventilated but include mechanical ventilation, which is initiated during high ambient conditions.

Supporting these facilities is the Plants Laboratory building, which is served by multi-zone air-handling systems and various exhaust systems.

"These provide close control of temperature, air velocities and air directions to facilitate research and to achieve regulatory compliance," says Hargreaves.

BC2 spaces within this building incorporate variable supply-air quantities to provide make-up air for the various variable speed fume cupboard and fume hood exhausts.

A local, dedicated steam generator provides process steam to humidifiers and autoclaves.

In more critical areas, such as the building's BC3 area, fan speed control is provided on the supply air fans to maintain constant supply air flow irrespective of filter loading. Fan speed control also provides on exhaust fans to maintain room pressure set-points.

A.G. Coombs' project engineer Emily McKernan, Assoc.AIRAH.

LOGISTICS MANAGEMENT

Establishing and controlling the logistics of such a large site proved challenging from both a site personnel and tool and materials perspective.

To help address this, A.G. Coombs had nominated, experienced area foremen looking after specific buildings.

"The very large site with multiple buildings spread out meant that the distances that needed to be travelled from the site sheds to the work fronts, and from work front to work front, were considerable," says senior project manager for A.G. Coombs, Ashley Trebilcock.

"To help manage this we worked with CPB Contractors to establish a number of satellite site sheds and facilities to keep travel times down to a minimum."

A dedicated 4WD site vehicle and trailer was also utilised to move materials and tools around the project site, often in muddy conditions.

"Additionally, because of the extent of works and the size of the site, we arranged for our suppliers to fit out their delivery vehicles with required lights and radios to enable them to drive directly onto the site and drop off the goods to the area foremen."

COMMISSIONING

A.G. Coombs worked closely with Jacobs during the commissioning phase to validate compliance with the biocontainment requirements during various operating scenarios.

McKernan says the dynamics of the systems in the BC2 and BC3 areas – particularly during equipment failure, start-up and shut-down – could not be known until commissioning, because of fan inertia and room tightness.

"The challenge was to ensure that enough flexibility was designed and built into the installed systems to allow adjustments during commissioning to meet the strict BC2 and BC3 requirements," she says.

The site also includes extensive gas, water and electrical metering to enable ongoing building tuning and energy benchmarking.

Such has been the high level of attention to detail throughout the entire project that most systems have performed as intended in the short period that the facility has been operational.

Of those issues encountered, such as minor controls fine tuning in the plants laboratory building, most have reportedly been due to users not being aware of the design parameters and limitations of the systems.

"We have received very positive feedback from the external third-party assessment inspector with respect to how their verification processes have been made much easier due to the quality of the installation," says A.G. Coombs senior project manager Ashley Trebilcock.

Trebilcock says practical completion has been broken down by buildings, with the first compound (Bees) granted in February 2015, with others following through to June 2016.

All but the Avian facility were completed and handed over to DEWR in October 2017, with the Avian facility expected to be handed over by the end of the year. ■

'Enough flexibility was designed and built into the installed systems to allow adjustments during commissioning to meet the strict BC2 and BC3 requirements.

PROJECT AT A GLANCE

Key design personnel

- **Architect:** Jacobs
- **Builder:** CPB Contractors (formerly Leighton)
- **Client:** Department of Agriculture and Water Resources (DAWR)
- **Consulting engineer:** Jacobs
- **Hydraulics engineer:** Rimmington & Associates
- **Mechanical services contractor:** A.G. Coombs
- **Third-party assessor:** Steve Coulter

HVAC equipment

- **AHUs:** Colair Refrigeration & Paragon
- **Air compressors:** Atlas Copco
- **BMS:** Johnson Controls
- **Boilers (HHW):** Aira
- **Chillers:** Powerpax
- **Controls:** Johnson Controls
- **Cool room equipment:** Burton Industries
- **Dampers:** Airepure / Celmec
- **Diffusers:** Aire Grilles
- **Duct:** Ductmakers / Rayson / Spiralduct
- **Fans:** Fantech / Pacific HVAC
- **FCUs:** Colair Refrigeration
- **Filters:** Airepure
- **Fume cupboards:** Dynaflow
- **Gas-tight dampers:** Flanders
- **Grilles:** Airepure
- **HCV units:** Aira
- **Heat exchangers:** Alfa Laval
- **Laboratory gases:** SGI
- **Laminar flow cabinets:** Fischer Biotech
- **Pumps:** BKB (Grundfos)
- **Sensors:** Johnson Controls, Testo, Wadsworth, Apogee & Mamac
- **Slab heating:** Rehau
- **Steam generators:** Simons Boilers
- **Steam equipment:** Spirax Sarco
- **Sterilisers:** Atherton
- **Trace heating:** Thermon & Heat Trace Engineering
- **VAV boxes:** Celmec

(Source: Jacobs and A.G. Coombs)