

Introduction

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Our Story

It's 2004 and the Winnipeg Airports Authority has chosen Stantec Architecture and Master Architect César Pelli to design a passenger friendly, state-of-the art facility replacing the city's dated 1960s-era air terminal building.



A team of experts from Canada and the United States was assembled with SMS Engineering selected to provide mechanical and electrical engineering design.

Staying true to the architect's vision for transparency, connectivity and an abundance of natural light, our engineers were instrumental in delivering a robust and energy efficient air terminal building.

The Winnipeg James Armstrong Richardson International Airport performs over 50% better than the Model National Energy Code for Buildings and is the first free standing airport in Canada, and the second in North America, to undergo a LEED® accreditation process.

All accomplished in one of the most widely fluctuating climates in the world - Winnipeg, Manitoba, Canada.

How'd we do it? This is our story.



A Team of Experts

“In 2004, the Winnipeg Airports Authority made the decision to replace its 1960s-era air terminal building. Of primary importance was the need for a building that was passenger friendly, fully barrier free, state-of-the-art, and most importantly, a robust terminal of the highest possible energy efficiency.”

As a member of the overall design team tasked with realizing the vision of Master Architect, Pelli Clarke Pelli, SMS Engineering Ltd. was challenged to survey the state of technology and determine the best mechanical and electrical approaches to this new facility.

We began by seeking best practices from two recent Canadian airport redevelopment projects.

The Mitchell Partnership / Smith + Andersen Joint Venture and Mulvey + Banani International provided expertise with respect to Toronto's Pearson International Airport, while Keen Engineering (now Stantec Consulting Vancouver) shared its lessons learned from designing Vancouver's International Airport.

This collective team, led by a Winnipeg-based firm, put together the significant mechanical and electrical systems which service this new state-of-the-art air terminal building.

The Plan

Over a number of months a series of meetings were held with designers regularly travelling to and from Winnipeg into Toronto and Vancouver and occasionally visiting the offices of Pelli Clarke Pelli in New Haven, Connecticut.



Weekly conference call meetings, hosted by Prime Consultant Stantec Architecture, continued the collaborative planning with experts joining in from all across North America.

The Heart of the System

“It became evident that the building which had provided heating, cooling and electric power to the airport campus for almost half a century remained a viable option as the new terminal's energy plant.”

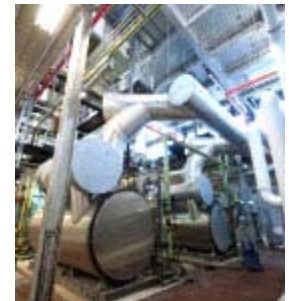


Tasked with determining the most efficient and cost-effective heating, ventilation and air-conditioning (HVAC) systems for the new terminal building, our designers initially conceived a fully standalone facility - making a clean break from the existing airport campus.

However, as the design work progressed, it became evident that the central utility building which had provided power to the airport for almost half a century remained a viable option as the new terminal's energy plant. An inventory assessment resulted in equipment upgrade and replacement.



New, state-of-the-art, low water volume steam boilers replaced two inefficient steam boilers that had heated the terminal and the administration buildings for 45 years.



The boiler upgrade complemented a recent chiller upgrade completed just prior to the start of the new air terminal building project.

With the heart of the airport campus system renewed, the designers moved on to the next phase.



A Giant Fish Bowl

“How do you efficiently heat and cool a giant fish bowl located on the windswept Canadian prairies”

While the upgrades to the Central Utilities Building were still on the drawing board, design began on the heating and cooling systems for the new air terminal building.

In keeping with a passenger-friendly design, the architects planned for an all-glass building making it easy for travellers to find their way, since they could spot their plane as soon as they entered the terminal. Additionally the glass allowed for an abundance of natural light reducing the need for harsh, artificial light.

This transparent 51,000 square metre, three-storey, north facing structure, enveloped by 500+ linear metres of glass presented an enormous mechanical design challenge. How do you efficiently heat and cool a giant fish bowl located on the windswept Canadian prairies?



Heating & Cooling Options

“The modeling data supported the designers' initial thinking, that a high-quality, energy efficient curtain wall, or window system, was essential to the project's success.”

Designers immediately began conducting detailed computer modelling of the glass wall's thermal performance, varying the temperatures to definitively determine the best heating and cooling options for this "fish bowl".

Modeling revealed the effect the "glass walls" would have on the facility's overall heating and cooling requirements and enabled the designers to finalize the plans for the central utilities plant equipment. Simulating the building's performance provided added benefit by drawing attention to the additional mechanical and architectural measures required to minimize energy use.

With the hard modelling data to support their intuition, designers began working with the architect and owner to incorporate what was considered a key element to the success of the project, a high-quality, energy efficient curtain wall system.

Light Spills

“The challenge became how to provide the significant cooling that would be needed to counteract the heat generated from the summer sun.”

Fifty-five skylights, an atrium, many thousands of square metres of glass walls and numerous clerestory windows allow light to spill into the terminal, giving travelers a sense of airiness.

These "light spills" also can be a source of solar gain, causing the building to heat up and making temperature control difficult in the summertime.

Using various modeling scenarios designers continued to fine tune the curtain wall blueprint.

Thermal and light studies revealed that wintertime solar energy could easily be absorbed into the building's heating system and re-used. The challenge became how to provide the significant cooling that would be needed to counteract the heat generated from the summer sun.



Solar Control

“Knowing where the most solar energy could be harvested, flexible plastic tubing was designed to be embedded in the concrete floors.”

Keeping transparency in mind, the architects and engineering design team began exploring ways to reduce the amount of solar energy making its way into the air terminal building.

The architects modified their original floor-to-ceiling, clear glass design to one of gradual opacity using a ceramic bonded, fritted glass. By increasing the "frosted" portion of the glass they were able to reduce light spills from the top while still enabling a clear view at eye level.

The architectural design was further modified with the inclusion of finned shades to the curtain wall. The shades "shadow" direct light at certain solar angles helping to control solar energy entering the building.

It was now the mechanical design team's turn to come up with a way to counteract the direct summertime solar gain to the floors.

The engineers studied where the sun would enter the building throughout the day for each day of an entire year. General trends were noted. With this, it was possible to know where the most solar energy could be harvested. In these locations, flexible plastic tubing would be embedded into the floors.

Hot summertime sun would be absorbed by cool water running through the tubes inside the floors and repurposed elsewhere in the building. This process would also reduce the need to cool the building with treated air – another energy saver and improvement to air quality. These tubes would also pipe the hot water needed for radiant floor heat in the winter.



The Sweet Spot

“The design challenge was how to determine the 'sweet spot' of floor temperature versus energy input to prevent damaging the concrete.”

The addition of plush carpeting provided a sense of visual warmth to the contemporary design of the air terminal building. It also increased the energy required to push the radiant heat up from the floor.

During moderate outdoor temperatures, the radiant heat system could operate as designed. When winter temperatures dropped, it was estimated that the system would need to operate near 60 degC to generate enough heat for the building.

The problem was two-fold – where to get the additional heat and how to deliver it without compromising the integrity of the concrete floors, which when heated to high temperatures for long periods of time would begin to deteriorate.



The first challenge was finding the right heat source. Most modern equipment produces heat at temperatures greatly beyond what was needed for the floors (82 degC versus the required 60 degC).

Options such as adjusting the boiler's temperature controls and cooling overheated water to the appropriate temperature were quickly eliminated. The designers were sure that they could come up with a more efficient and less equipment damaging way to cool the water, but for now the issue would need to remain unresolved on the drawing board.

While the heating system was being ironed out, designers worked to ensure the cooling mode for the floor would be viable.

Carefully controlled cooled water would be circulated through the floors absorbing sunlight as required. Sensors determine the dew point temperature of the air adjacent the floor to prevent dangerous puddles on tiled walking surfaces and condensation of water on carpeted floors.

A modeling test of a hot, humid summer day showed no condensation would occur should a portion of the curtain wall become shattered.

Cascading Down

“The building heating system 'cascades' water from a high temperature boiler through numerous heating stages - making the most of the energy consumed and providing a solution for the radiant floor heating system.”

Designers continued to wrestle with how to most efficiently provide low temperature heating water for the radiant floor heating system. Cooling overheated water wastes energy and running boilers at lower temperatures would damage the units.

A concept that appeared viable was to use a heating cascade, where water from the boiler is passed through numerous heating systems in series, with each, in turn, utilizing the heat from the water before passing it along to the next system.

Research on state-of-the-art heating plants also revealed a product produced in Montreal that could offer an innovative solution to make the entire system work.

This innovative flue gas condensing economizer 'cascades' water from the boiler through numerous heating units with each, in turn, utilizing the heat from the water before passing it along to the next system.

In the CUB, high temperature water (82 degC) is generated by traditional high-efficiency, non-condensing boilers and then pumped approximately 1,000 metres from the CUB to the air terminal building. Once in that building, the water is first pumped to high-temperature devices needing a high volume of hot water, like wall-mounted radiators and heaters located near entries.

Instead of returning this water to the boiler for reheating, as is done in most buildings, the heating system directs this nominally cooler water to the next stage of the cascade, the air handling system.

Air handling systems combine fresh outside air with used inside air to efficiently ventilate a building. Cold, fresh air that needs to be warmed to room temperature is pushed through water-fed heating coils before being added to used air.

In this building, coils are designed to accept water from the radiators at a medium temperature and use it to heat the outside air. The temperature of the used water is lowered to near body temperature before finally pumping it to the boiler plant.

The Energy Bus

“The concept is similar to a city bus. The bus goes around its route, and passengers get on and off. In this case, the passengers are the energy.”

An airport has many spaces requiring constant cooling including electrical rooms with large transformers, computer rooms, retail stores and restaurants.

In this building, unlike typical cooling systems that expel heat collected from these types of spaces directly outside, the water loop system recovers heat considered to be 'low grade' and generally not useful for many building applications.

Combining the previously mentioned cascading heating system with an efficient water loop designers were able to capture energy in order to utilize it elsewhere in the air terminal building.

This water loop operating at a lower temperature extracts and transports energy from local water-to-air heat pumps to other areas like (finally) the radiant floors.

The concept is similar to a city bus. The bus goes around its route, and passengers get on and off. In this case, the passengers are the energy; it gets on at the heat pumps, and gets off at the floor, and the bus goes around and picks up more passengers.

Depending on the outside conditions and the operation of the building, the medium temperature water is used to boost the low temperature water temperature if insufficient low grade heat is available. If the water temperature gets too high, only then is the energy expelled outside the building, using eight very large fluid coolers.

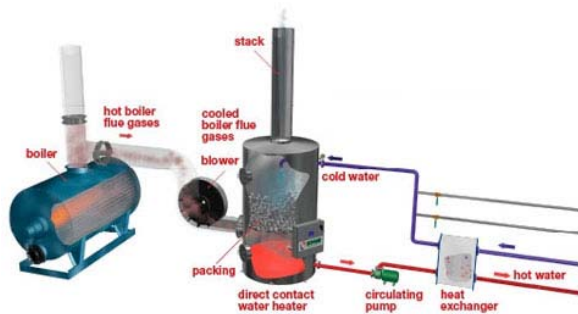
Squeezing Heat

“The end result is a heating plant for the new air terminal building that is nominally above 95% seasonal efficiency - this for a 51,000 square metre building.”

The flue gas condensing economizing unit mentioned earlier adds to the efficiency mix of this building by capturing waste energy.

When natural gas is burned it produces carbon monoxide and water vapour as the products of combustion. Water vapour is essentially steam at the temperature it leaves the boiler and the cause of the 'steamy' look to the exhaust from the chimneys. This steam contains significant energy and the flue gas condensing economizing unit captures this energy so it can be repurposed in other equipment.

It works like this; an extraction fan draws the boiler exhaust into the unit, pushing it up and out the chimney of the CUB while a spray of water is simultaneously pushed down against the flow of the exhaust. The contact area between the exhaust and spray is increased by a packing of stainless steel rings.



Heat from the exhaust is transferred into the water spray. This heated water spray is essentially the same water returning from the New Air Terminal Building but is at a temperature much lower than can be used in the boilers without causing deterioration. The flue gas condensing economizing unit is used to raise the water temperature above 60 degC so that it can be used in the boiler.

The particular flue gas condensing economizing unit used on the project also has a natural gas burner built in that allows it to act as an additional boiler. As a result, the flue gas condensing economizing unit is used as the primary heating source, due to its very high efficiency, with the traditional high-efficiency boilers operated only when the building needs greater amounts of heat.

The end result is a heating plant for a 51,000 square meter building that is nominally above 95% seasonal efficiency.

Air – Only Where Needed

“This fountain of air treats only the area where people are present, leaving the remaining three-story high space alone.”



As earlier mentioned, large air handlers – some twenty units ranging from as small as 150 L/s of air flow to nearly 50,000 L/s – ventilate the new air terminal building by mixing fresh untreated air with interior used air.

Regrettably, many of these units are required to pass this treated air through the building just one time and then exhaust it outside – not very energy efficient.

To help increase energy efficiency, heat recovery was included on most of the building's exhaust systems. The system captures energy from air, either heated or cooled, being ejected from the

building and retrieves it to ventilate air entering the building.

To also keep energy use in check, and when the right conditions exist, free cooling modes allow air handlers to use fresh air to ventilate the facility without having to heat or cool the air.

Once the air is treated, there is one of three modes for getting it into the occupied spaces.

A series of "eyeball" diffusers located below the clerestory windows in the departures hall jet small volumes of air at a high velocity causing air movement with minimal use of fans.



Displacement ventilation in the baggage claims hall pushes air through five large round grills atop each of the three baggage carousels causing a fountain effect of air that gradually drifts down to the floor. This fountain of air treats only the area where people are present, leaving the air in the remaining three-story high space alone. To prevent the air near the ceiling from overheating, invisible return air gaps were incorporated into the skylight housings.



The third critical area is the passenger holdrooms. These areas incorporate both a continuous band of jet diffusers and a series of stainless steel 'totems'.

In heating season, the totem's lower back side registers are opened to wash the curtain wall with warm air, preventing possible condensation. In cooling mode, the upper register is used to push cool air high into the holdroom where it will begin to gently drift down on passengers, minimizing drafts.

Pumps and Fans

“The end effect is a system that uses the 'right' amount of power for motors, rather than the "off or full blast" approach used in older buildings.”

Throughout the New Air Terminal Building are multiple electric motors used to power HVAC equipment. Whether powering pumps, fans, or air handlers, the majority of HVAC motors are controlled using variable frequency drives or VFDs.

A VFD is a computerized electrical device that acts like a giant dimmer switch for a motor, with the one exception that the dimming action is controlled by the building's control system.

Depending on the number of occupants in an area, the control system may sense that more fresh air is required and call for the fan motor to speed up. With fewer occupants, the reverse occurs.

There are typical sequences of operation for most major equipment. The end effect is a system that uses the 'right' amount of power for motors, rather than the older "off or full blast" approach used in older buildings, where motors could only be on or off.

Air Quality

“The end result is an air filter only twice the width of a traditional home furnace filter that achieves a very high efficiency (85%+).”

The overall building is controlled by a series of distributed computers that measure ambient conditions, outside conditions, and the status and performance of equipment.

Based on sophisticated routines, the computers make decisions on how the building's environment should behave. To elaborate on the previous example of fans speeding up or slowing down based on occupancy, carbon dioxide and volatile organic compound (VOC) sensors throughout the building measure the air quality. Outside air quality is also measured and the two are compared. If the outside air is poor, perhaps due to jet plane exhaust for a certain period of time, the fresh air intake is minimized. If the outside air quality is good and the inside is poor, more fresh air is brought in. Temperature is automatically controlled and regulated in all spaces.



Air quality is also protected with air filtration devices inside the air handlers. A unique electrostatic filtration system is used which has many benefits.

Primarily, it allows for the highly efficient filtration of air with little fan horsepower. In simple language, a filter acts as a screen that captures contaminants such as dust, hair, and potentially bacteria or spores that are in the air.

Typically, this is accomplished by using a very fine mesh material. The finer the mesh, the more power is required to push the air through the mesh, as the holes are smaller.

Highly efficient filters require a lot of power to get the air through the filter. In the case of this project, the mechanical designers proposed using a new technology for filters. Rather than traditional fine-mesh filters, the use of coarser mesh filters with electrostatic enhancement was proposed. This product introduces an electrostatic filtration system on a very slim filter, where electricity is used to capture the very fine contaminants. The end result is an air filter only twice the width of a traditional home furnace filter that achieves a very high efficiency (85%+).

In fact, SMS Engineering Ltd. proposed an equivalency to the LEED Canada programme which was accepted and may lead to an innovation point for the project. As Martin Cash, Business Writer of the Winnipeg Free Press wrote in his feature *Terminal Case of Energy Efficiency*, "Instead of 30-centimetre-thick filters, which would have required massive fans and much more powerful motors (and much more energy consumption), SMS showed electrically charged filters about twice the thickness of a home-furnace filter would provide just as thorough air treatment with much less energy consumption."

What all of this means to the Winnipeg Airports Authority is that the air that is passed through the New Air Terminal Building is being filtered to a very fine level with little energy being exerted to do so.

Less Water

“End-of-line instantaneous water heaters for a just-in-time approach to hot water generation using blue energy.”

Airports use a lot of water; washrooms, kitchens and maintenance. As part of the overall energy efficiency approach to this air terminal building, the mechanical design team considered low flow plumbing fixtures throughout.

All washrooms are equipped with low flow toilets, urinals, showers, and low-flow faucets.

Additionally, hot water for use is typically generated by end-of-line instantaneous water heaters for a just-in-time approach to hot water generation. Rather than keeping very large storage tanks hot using natural-gas fired heaters, electric point of use heaters are used to generate hot water only when required.

In Manitoba, where electricity is 98% generated through hydroelectric dams, this approach also minimizes the carbon footprint of the building, using nearly green (*also called blue*) energy.



Lighting

“Most of the lighting is designed to be off in the daytime, saving significant amounts of energy.”

With the abundance of natural light streaming in from the 55 skylights, atrium, curtain wall and clerestory windows it would be easy to think that the lighting design of the new air terminal building would be a snap.



And, for most of the day it is, as artificial lighting levels in the departure, baggage claim and holdroom areas are designed to be very low, or off completely.

The challenge was how to simulate this natural light when needed to discreetly and efficiently emphasize the magnificent architectural features of this expansive facility.

Upon entering the air terminal building from the street, travelers are greeted with a stunning abundance of natural wood. Interpreted by some as waving fields of wheat and by others as sandy beaches, it was essential the artificial lighting used here exude a sense of warmth.

During four long nights, electrical designers worked in the departures hall adjusting the numerous metal halide lights to eliminate shadows and reduce glare. The result is stunning - and uniformly "uplit" - golden-toned ceiling with an expanse of open area bathed by "downlights" tucked into the black separation bands of the ceiling.

Another creative use of light is in the passenger holdrooms. Fixtures used to light adjoining retail areas are strategically positioned to reflect light off of the dropped t-bar ceilings back into the passenger waiting areas supporting a relaxed environment.

Indigo-coloured LED rings surrounding the random constellation of skylights greet passengers and simulates a prairie sky. This feature leads the eye up, providing a striking visual contrast to the predominately white air terminal building.

The exterior of the building is lit using an array of LED light fixtures with the front canopies lit by linear downlights and front soffit overhangs as well the expansive 21 metre-long east and west overhangs illuminated with linear uplights.

Systems Design

“Daily, thousands of people pass through the air terminal building, and as guests or employees, it is important they be safe.”

Architecturally, the building is designed with ample doors and exits, but as with any secure facility with automatically locked doors and controlled access points, it is vital these areas be interconnected with the fire alarm system for safe and rapid evacuation if required.

Fire alarm systems are designed such that initial reports of fire incidents notify airport duty personnel and put the building personnel on alert. A short period of time is allowed for the Authority to determine if a event warrants evacuation and shut down of this vital facility. If the fire signal is confirmed, the evacuation alarms are sounded, airport operations are suspended, and normally secure areas are opened to allow occupants to exit outside safely. If the situation is deemed safe, day-to-day activities continue without disruption.

Working closely with the Winnipeg Airports Authority security and IT designers, pathways for both voice/data cabling and security door access control and CCTV systems were designed. Being such a complex, multi-tenanted, common use facility means the IT systems are extremely complex and important to the building's day to day operations. In all, there are over 3.5km of cable trays within the building, supporting many thousands of cables.

As a state-of-the-art computerized building featuring, it features two large-scale data rooms that house all of the main components required to run a modern air terminal building including airport operations and coordination, signage, PA systems, check-in counters, baggage handling control, and flight information display systems.



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Emergency Generators

“Tasked with designing a building to be as reliable and resilient as possible, the designers provided a unique feature on this building.”

Resiliency and reliability are key characteristics of a modern airport. As air transportation remains highly important for the timely movement of people and goods, the departure and arrival points are important elements. With the experience of the use of the Winnipeg airport as an international emergency landing point during the September 11, 2001 events, consideration was made of how the electrical design could accommodate ensuring the new air terminal building could best withstand possible loss of utility power.

The building incorporates two-2000kW diesel generators, each capable of operating for 24 hours from large fuel storage tanks. The aim is that aside from a short dip in the lights, the building would continue to operate even during a power outage.

After power is restored, the generators automatically synchronize with the utility power system to seamlessly transfer power (without even so much as a dip in the lights) from generator power to utility power.

At the time of design, it was one of the first airports in North America to have full on site back up diesel-electric generation.



Power Distribution System

“An airport is an important building to the community and is expected to be operational at all times.”

As a further consideration to ensuring the new airport would always remain "up", consideration was made to the utility power supply. Unlike most buildings that have only a single source of power from Manitoba Hydro, this one has two.

Electric power is provided to the airport property at 24,000 volts, and is eventually knocked down to 600 volts in the airport by high capacity transformers in both the CUB and the new terminal.

With a simple flick of a switch, power can be redirected from either of the two main feeders.

Throughout the building there are multiple electrical rooms, co-located with six voice data rooms. These rooms stacked in such a way as to vertically route power and voice/data traffic through the building without much visual impact on the open, airy theme of the building. Each electrical room comprises a multitude of 600V to 120/208 volt transformers and panel boards.



One important design feature is that holdrooms are provided with laptop charging stations on bar style tables a thoughtful touch in today's world of mobile technology.

Artwork Lighting

“Our designers illuminated both the Richardson Statue and Ione Thorkelsson's pieces using intricately designed and precisely aimed lighting hidden within the building's architecture.”

Working closely with Warren Carther, Joel Berman and Nancy Chew, our electrical designers assisted these talented artists with making real their visions of how their sculptures would be internally, or locally illuminated. From the internal LEDs, to colour changing lamps, to backlighting, the public artwork program in the new terminal building is brought to life through specialized lighting systems.

Our designers illuminated both the Richardson Statue and Ione Thorkelsson's pieces using intricately designed and precisely aimed lighting hidden within the building's architecture.



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