The Rotunda

300 Frank Ogawa Plaza, Oakland, CA

Wireless Pneumatic Thermostat Project

BUILDING PROFILE

Located on the eastern edge of Frank Ogawa Plaza in downtown Oakland, the Rotunda was the last HVAC energy efficiency project under the Oakland Shines program. 300 Frank Ogawa Plaza consists of two buildings, one structural steel building originally constructed in 1911 and a reinforced concrete building built in 1924. After the 1989 Loma Prieta Earthquake the building was deemed unsafe and was vacant until it re-opened in 2001 after major renovations. The highlight of the Rotunda Building is an elliptical glass dome soaring over 120 feet off the atrium floor, trimmed in gold leaf. The building has 352,000 square feet of rentable space, mostly for business offices, but 75,000 sq. ft. on the first floor was built for retail. The Rotunda is a popular venue for special events and therefore has special lighting and HVAC systems in place to handle the increased load. The Rotunda has been through many energy efficiency projects and upgrades, including one in 2003 that helped the building earn an Energy Star rating. However, the building still uses a network of pneumatic tubes with varying air pressure to control the air conditioning systems. This is an outdated technology and although the building runs efficiently, the old technology inherently means there is room for improvement.

HVAC SYSTEM

The HVAC system at the Rotunda utilizes a Variable Air Volume (VAV) system with perimeter reheat and VAV boxes at each zone. Each VAV box has an associated pneumatic thermostat in the zone to control the airflow dampers and reheat coil valves. The boxes receive air from one of three AHUs on each floor (22 total Trane units). Each AHU is equipped with airside and waterside economizers. The units located toward the interior of the building draw outside air from a main air shaft that opens up to the roof. All of the units have refrigerant (D/X) cooling coils in addition to pre-cooling coils that use cooling tower water when ambient conditions are suitable for water-side economizing. During high ambient temperatures, the compressors on each unit run and the cooling tower water is diverted to cool the compressors. Previous to the Oakland Shines project, each unit used pneumatic duct-static-pressure (DSP) sensors to control Inlet Guide Vanes (IGVs) on the inlet to the fans. These DSP controlled IGVs were standalone systems. The re-heat coils receive hot water from two vintage 1985 Parker boilers with an output capacity of 4,400 MBTU/hr located on the roof.

THE TECHNOLOGY

The Wireless Pneumatic Thermostat (WPT) by Cypress Envirosystems is a relatively low-cost retrofit which allows a pneumatically controlled HVAC system to have all the same functionality as a Direct Digital Control (DDC) system. The retrofit is inexpensive in comparison to a full

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DDC retrofit because it doesn't require removing the old pneumatic tubes and controllers and re-wiring the entire building with electrical wiring and digital controllers. These WPTs can be installed in a matter of minutes by

WPT—Installs in minutes

simply removing the old pneumatic thermostat on the wall and plugging the branch and main line pressure tubes into the back of the WPT. Each WPT has a pressure transducer in it that converts a pneumatic pressure signal (both branch and line pressures) to a digital signal. The digital signal can then be wirelessly relayed back to the building's Energy Management and Control System (EMCS) where the digital signal is stored. The Cypress system utilizes a hybrid mesh wireless network. This network has a backbone of wireless repeaters running through the center of the building. The backbone receives the signals from each of the new thermostats and transmits the data back to a "Green Box", a Cypress product that can be used as a control system for the thermostats. Management at the Rotunda elected to have the data from the Green Box relayed directly to its own EMCS (Automated Control Systems) using a BACnet standard protocol.

PROJECT OVERVIEW

The Rotunda has approximately 261 pneumatic thermostats controlling space temperature throughout the building. All of these thermostats were replaced with Cypress WPTs.

In addition, this project included disabling all 22 IGVs and retrofitting each AHU with VFDs to control fan speed. Many of the original pneumatic DSP sensors had failed and as a result, 19 of the 22 units were fixed at 100% flow. The new VFDs are controlled with new, wireless duct-static-pressure sensors. The wireless network for the WPTs runs through the center of the building from the top floor through the basement where the Greenbox is located. Honeywell was contracted to do the install of the thermostats and *Automated Controls* facilitated the mapping of the thermostat data into the existing front end. The front end now has detailed graphics of every zone temperature in real time. Additionally, every thermostat has all of the points it can monitor being trended in the EMCS. These points include branch pressure, line pressure, zone temperature, zone set point, and battery level.

ENERGY SAVINGS

The advantage of a DDC system is the feedback and zone control the thermostats can provide to the building's EMCS. Feedback signals allow energy saving control strategies to be programmed into the EMCS. By replacing every thermostat in all the zones with Cypress WPTs, the building operator now has insight into how each floor is being controlled, and effectively has all the same control options as if there were a DDC system in place. The Rotunda was able to put the following energy efficiency measures in place.

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1. Temperature set-point policy - The building now has a global temperature set-point policy. This measure essentially takes temperature control from the occupants and puts it in the hands of the building engineer. Invariably, when occupants have control there are problems such as leaving thermostats in extreme positions overnight, or adjacent offices calling for cooling and heating at the same time. Having a set point policy means that all zones will be a constant temperature all the time which eliminates behavioral inefficiencies. This measure was verified by trending temperatures in a representative sample of zones and confirming that temperature was (relatively) constant.

2. VFD controlled supply fans - The energy benefits from this measure are two-fold: increasing the efficiency of the fans and returning flow control to 19 units. As previously mentioned, 19 units had failed DSP sensors and were therefore forced into 100% flow at all times. The new VFDs now control fan speed based on DSP and use less energy when flowing less than 100%. Slowing the fan speed with a VFD is much more efficient than controlling flow with IGVs and having a constant fan speed.

3. Duct-Static Pressure Reset based on zone satisfaction- This is a typical measure in buildings with DDC. This measure employs a trim-and-respond algorithm which examines zone set point and zone temperature. If the zone is satisfied, then the Duct Static Pressure (DSP) set point is reduced until the zone calls for heating or cooling. A lower DSP means the fans are run slower and use less energy. This measure was verified to allow the DSP to drop seven tenths of an inch of water (from 1.5” to .8” WC).

4. Occupancy override - This measure takes advantage of the individual control the building engineer has over each thermostat. Upon the start of the project, the Rotunda was approximately 8% vacant. With the old pneumatic thermostats, there was no way of shutting off air to the vacant zones. The WPTs can be put into an “override” mode which tells the thermostat not to call for cooling or heating, putting the VAV box into minimum position at all times regardless of zone temperature.

The verified annual savings of these measures combined is: 98 kW 419,445 kWh 3,835 Therms

PROJECT FINANCIALS

Total Project Cost:	$ 314,620
Cost to Customer:	$ 100,000
Simple Payback:	1.4 years
Net Present Value*: (over 10 years @ 3% discount rate)	$ 486,660

* Based on energy savings only; maintenance benefits are not included in calculations.

PROJECT BENEFITS

- Running the fans at lower speeds with VFDs has significantly decreased duct noise in all of the occupied zones.
- Increase in occupant comfort due to reduced noise. Additionally, the building operator can see hot/cold spots in the building and address the causes sooner.
- Lower energy use translates into a reduction in environmental impact/carbon footprint of the building.