ENERGY ASSESSMENT REPORT

Museum London, London, Ontario

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1. Executive Summary

A comprehensive ASHRAE Level II energy audit was conducted by Blue Sky Energy Engineering & Consulting Inc. on March 26th, 2014 of the Museum London facility. Museum London, built in 1980, is located on 421 Ridout Street North, London, Ontario. The primary objective of this study was to uncover energy conservation opportunities within the facility which lead to tangible energy and cost savings.

The following report is divided into several sections. **Section 2, Facility Description**, provides a summary of the current facility, complete with descriptions of the main mechanical and control systems, lighting, building envelope, plug loads and operations. **Section 3, Current Energy Performance**, details and discusses current utility rates, historical consumption patterns and a facility energy balance. Electricity and steam consumption are compared to weather data and the subsequent regression analysis forms the basis of a facility energy baseline. **Section 4, Energy Conservation Measures,** discusses the studied and recommended energy conservation measures (ECM) broken down by system. **Section 5, Points for Consideration**, discusses items worth reviewing but require additional investigation and the final **Section 6 summarizes nexts steps**.

Over 26 conservation opportunities are reviewed in this report with an additional 4 items for your consideration. **Of the list, 22 energy conservation measures (ECMs) have been recommended and if executed have a combined savings of $70,000/year (2,300 Mlbs of Steam and 260.8 MWh of Electricity) with an ROI of just over 1.2 years.** Table 1 (next page) summarizes the recommended ECMs with estimated savings, costs and available government incentives. A simple rate of return has been calculated for each item and listed on the table (before and after incentives). The cost and savings estimates are within +/- 30% and +/- 50% respectively as required by the Ontario Power Authority (OPA) requirements.

Included in this report are available government incentives from the **Ontario Power Authority's (OPAs) saveONenergy program.** In order to take advantage of these financial incentives, it is important to work with London Hydro and Union Gas to ensure that approvals are obtained from the program before work is undertaken.

Please note that the basement rental space (IT group) is submetered and was considered out of the scope of this project. In order to complete a facility consumption breakdown, electricity use for the basement rental space was estimated based on the demand reading taken from the meter the day of the audit, as historical consumption data was unavailable.

There is significant opportunity at Museum London to improve the energy performance of the building by delivering the suggested projects. Of the recommended ECMs, the items with the largest impact are the following:

Projects:

- Demand controlled ventillation for top floor of gallery
- Insulation of short absorption manifold (humidifiers)
- Project for Consideration: Variable speed drives (VSD) on AO1 and AO2 supply fans and RF2

Building Controls:

- Enthalpy control: replace outdoor air humidity sensor
- Seasonal humidity and temperature setbacks

HVAC System General:

- Verify Operation of all air dampers
- Replace clogged air filters in air handling units and check coils for buildup
- Fix steam leaks on short absorption manifold (humidifiers)

Type	Description	Annual Utility Reduction / Savings			Estimated Cost $	Simple Payback	Incentive $	Payback c/w Inc.
		Type	kW, kWh, m^3	$				
Heating / Cooling	Verify Proper Operation of all air system dampers	Steam Elect.	Reduction	TBD	Internal Labour	< 1yr	N/A	
	Repair Outdoor Air Humidity Sensor for Enthalpy Control	Steam	Reduction	TBD	$400	< 1yr	N/A	
	Demand Controlled Ventilation for Upper Gallery	Steam Elect.	1020 Mlbs 7210 kWh	$17,500	$4,000	< 1yr	$2,000	< 1yr
	Preventative Maintenance cooling coils and air handling air filters.	Steam Elect.	Reduction	TBD	Internal Labour	< 1yr	N/A	
	Replace 2 Electric Heaters with Under Desk Radiant Panels	Elect.	5.2 to 15.6MWh[1] 2.6 kW	$565 - $1700	$200	< 1 yr.	50% = $100	< 1yr
	Repair and run ceiling fans in main storage vault	Elect.	Modest	~$950	$2,000	2.1 yrs	N/A	
	Chiller Operation	Elect.	No Change				N/A	
Controls	Seasonal humidity and temperature setbacks	Steam Elect.	140 Mlbs Reduced kWh	$2,400	0	Immediate	N/A	
	Reduce Set point Temperature of Loading Dock area (Winter)	Steam	3-4% reduction in space heating per 1°C setback		0	Immediate	N/A	
	Temperature Resets	Steam Elect.	3-4% reduction in space cooling per 1°C setback		0	Immediate	N/A	
Steam System	Performance Monitoring of Steam heat exchanger	Steam	Reduction	TBD		< 2 yrs	N/A	
	Fix Steam Leaks on Short Absorption Manifold	Steam	500 – 750 Mlbs	$8,300 – $12,500	TBD		N/A	
	Install Insulation on Short Absorption Manifold	Steam Elect.	Significant	$13,000	$24,000	2 yrs	N/A	
Domestic Hot Water (DHW)	After hours shutdown of building DHW pump.	Elect.	680 kWh	$95	$200	2.1 yrs	10¢/kWh = $68	1.2 yrs
Building Envelope	Draft Reduction – building infiltration	Steam Elect.	Heat Loss Reduction	TBD	$1000	< 5yrs	N/A	
Lighting	Replace T8 lamps with higher efficiency T8 bulbs (28W) – assume 100 bulbs	Elect.	710 kWh	$70	$100 ($1 incremental/ bulb)	1.4 yrs	$100 ($1/bulb)	Immediate
	Retrofit T12 Lamps with T8 bulbs and ballasts.	Elect.	146 kWh	$15	$200	13 yrs	$51[2]	10 yrs
Plug Load	Overnight Shut Down Computers	Elect.	1405 kWh	$140	$0	Immediate	N/A	
	Regular cleaning of condenser coils on fridges / freezers.	Elect.	Reduction	TBD	Internal Labour	Immediate	N/A	
	Replace older chest freezer.	Elect.	Reduction	TBD	TBD	TBD	10¢/kWh	TBD
	Vending machine mizer	Elect.	Reduction	$50	$200	4 yrs	10¢/kWh	TBD
Project Under Consideration	Variable Frequency Drive (VFD) on AO1 and AO2 Supply Fan and RF2 Return Fan	Elect.	187,500 kWh Demand Redtn. TBD	$22,000	$40,000	1.8 yrs	$18,000[3]	1 yr

Table 1: Summary of Recommended Energy Conservation Measures

[1] The savings is based on estimated usage.

[2] This incentive will need to be combined with other lighting incentives to quaivy because of a required $1000 minimum per application

[3] This incentive is based on the Engineered application and requires detailed energy measurement before and after the installation. A simpler application (called Prescriptive) is available however the incentive is not as large.

The savings listed in Table 1 above are specific to each measure and do not account for possible interactions if multiple projects are undertaken.

2. Facility Description

General Overview:

Museum London, located on 421 Ridout Street North, London, Ontario was built in 1980. The 89,000 ft^2 facility is used as museum with public spaces, vaults which house the museum's collections, office space, a restaurant and cafe. The facility has had several significant upgrades including a site wide lighting retrofit in 2013 and two new chillers in 2009. An outside wall cladding replacement was completed around 2008 and the roof skylights, located in almost every upper space, were upgraded and replaced three years ago.

The museum is open to the public from 12:00 – 5:00pm from Tuesday to Sunday with the exception of Thursday which is open late to 9:00pm. Summer hours, which start on Victoria Day weekend and finish on Labour Day weekend have the museum opening to the public one hour earlier (11:00am). Twenty (20) full time staff work in the building with between 2 and 25 volunteers helping with the various programs. The staff hours are generally between 7:00am and 5:00pm.

Table 2 below, lists several of the buildings basic features. A detailed list of the major building equipment can be found in Appendix D.

Item	Details
Address	421 Ridout Street North, London
Site Contact	Cydna Mercer, 519-661-2500
Facility Type	Museum Building
Year of Construction	1980
Area	89,000 ft^2
Floors	Three (and a partial mezzanine)
Lighting	Various. T8, LED, CFLs, (small number of T12 and incandescent bulbs)
Primary Heating System	Purchased district steam which provides hot water to AO6, fans, zone heating coils, unit heaters and DHW tank. A packaged roof top unit (natural gas) serves the main restaurant.
Supplementary Heating System(s)	Electric heating coils in a small number of ducts for zone heating (approximately 12 units). Secondary electric coils in DHW storage re-heater.
Cooling System	Two 130 ton Trane reciprocating chillers with cooling tower used in summer. One 60 ton reciprocating chiller (air cooled) used in the winter. Chilled water coils are located in all six main AHU and in the outdoor air duct for dehumidification.
Mechanical Ventilation	Six (6) air handling units serve the main spaces of the museum with one additional roof top unit serving the main restaurant. Each of the main units have steam humidification and cooling coils. AHU6 also has a hydronic reheat coil.
Humidification	Purchased steam is used directly in AO1 to 6 for humidification.

Table 2: Summary of Museum London Main Systems

HVAC Systems:

Stability in both temperature and humidity within the facility is of paramount importance to museums to both protect the collections and be considered an ASHRAE "A" Class Control facility to store or display Certified Cultural Property. Two subcategories exist within this rating: one with seasonal setbacks, and one with no seasonal setbacks. As per recent advice from a representative of the Canadian Conservation Institute (furnished to the consultants via an internal museum email (see Appendix A), recommended that the Museum review the seasonal setback option for building control.

The building is conditioned by seven (7) separate air handling systems, the first six are labeled A01 to A06. AO1 to 5 are located in the main basement mechanical room and AO6 is in a separate location also in the lower floor. AO1 to 6 have cooling coils and use steam for humidification. AO6 has an additional heating coil for preheating outdoor air. AO7 is a packaged roof top unit that serves the main restaurant only. Space heating is primarily hydronic reheat units in the ducts as well as ceiling mounted hydronic unit heaters. A small number of electric heating units are currently located in the office ducting and main storage vault.

The supply air temperature to the spaces is operator set (approximately 16^{o}C in winter, 22^{o}C is summer). The outdoor air (OA) dampers adjust along with the chilled water valves to maintain this setpoint. In the summer, the economizer will minimize OA and exhaust air (EA) dampers positions if the outdoor air temperature is above a set point or if the chillers are running. The dampers will also adjust based on the mixed air temperature. The consulting team was told that the OA dampers were operator set at 5% the day of the audit. Due to an outdoor humidity sensor failure, enthalpy control is not currently being used. This control feature compares the temperature and humidity outside vs. inside and controls outside air quantity so the economizer free cooling only operates when the outside air will not impose a humidity load on the spaces.

The zone temperature setpoints for winter heating are preset by the building operator (21-22^{o}C) with some thermostats located in the office area and restaurant that allow setpoints to be modified by +/-4^{o}C. Some staff with workstations located in the lower office area along the west windows said that their work spaces tended to be too cold in both the winter and summer. Under desk electric heaters were used by staff members to warm these office spaces in both seasons.

The hot water loop used for hydronic heating is supplied by heat exchange with purchased steam from London District Energy. The steam is currently provided to Museum London at approximately 118 psig. The steam pressure is reduced to 15 psig and then used directly for humidification in the air handling units. The hot water loop also heats domestic hot water (DHW) to 50^{o}C. An additional DHW storage tank is fitted with electric coils for reheat when required. The DHW storage tank is set 5^{o}C cooler than the heating unit so that the electrical reheat is minimally used.

Cooling is supplied by three reciprocating chillers which reject heat to cooling towers. Two newer units (2009), located in the main mechanical room, are used in the summer and were offline at the time of the audit. The smaller unit (60 ton) is located in the upper level mechanical room and used for winter operation. All three chillers were manufactured by Trane. An additional cooling unit is located on the roof and used to cool computer servers located in the basement of the museum. This is a rented space and is submetered separately and as such, was deemed out of scope of this report.

Each air handling unit has differential pressure measurement across the filters. It was noted during the audit that the differential pressure across filters in A02 was 3.4"H_2O, in contrast to other filter banks which ranged

from 0.4 to 0.7"H_20. If the measurement is accurate, this indicates the filters are dirty and need to be changed. It was also noted that some of the field instuments (temperature and pressure indicators) used to trouble shoot the system were not working.

A small tank located in the mechancal room receives hot condensate from the steam system and delivers it to the drain. The temperature of the condensate was measured to be 71°C the day of the audit and it is estimated that the flow of condensate was at least 5L/min (but was not measured). This is currently a wasted heat loss that could potentially be captured and used.

The zones for each air handling unit are shown below. Please note that the zones listed below reflect a new report (published April 2014) from a mechanical contractor employed by the museum. The contractor checked and confirmed the routing of facility ducting. Please find the summary page of this report, furnished to Blue Sky by Museum London, in Appendix B.

Air Handling Unit	Room
A01	Upper Gallerys: 206, 207, 210, 201
A02	Upper Gallerys: 202, 203, 204, 205 Basement Vaults: 020, 025, 026, 028, 030
A03	Lower Gallery: 009; Lower Hallway 024 Main Floor: 110,111/111A, 104,112, 113, 114, 115
A04	Main Floor: 120, 121
A05	Lecture: 004, 007; Offices: 010, 014, 018, Mezanine, 054 Storage Vault: 054, 054A
A06	Basement: 042, 046, 047, 049, 050, Mezanine

Table 3: Summary of Zones Served by Various Air Handling Units

Building Envelope:

The building envelope is constructed from steel reinforced concrete with an outside layer of metal cladding. The outside cladding was upgraded approximately 6 years ago. 85% of the roof surface is a concave architectural design constructed from reinforced concrete with a top layer of metal cladding. Several leaks were pointed out during the audit which indicates significant infiltration or exfiltration may be occurring. The smaller flat portion of the roof is also similar construction but the top layer is rolled asphalt. The consulting team was made aware that the Museum is considering replacing the roof next year and we are therefore recommending reviewing the option of adding insulation. Heat loss can be significant through the roof in the winter as heated air will rise to the ceiling in the upper gallery spaces.

The windows are a mixture of original single and upgraded double glazed units, mostly aluminum framed. Some spaces have manual window shades and blinds. Many fenestrations had condensation forming on the windows and frames. Doors to the outside are a mixture of metal and fully glazed doors used for emergency exits, and staff and public access. The auditors observed condensation on a number doors, and drafts between some of the doors and frames.

The majority of the concave roof sections are fitted with sky lights that were replaced approximately 3 years ago. In the gallery areas, the skylights have retractable shades that are currently left closed. The skylights in

the main atrium also have retractable covers but are typically open. It was noted that the aluminum frames around the skylights were cold and covered with condensation. A proper thermal break may not have been installed with these window frames causing the inside surface temperature to cool below the dew point.

Lighting:

A major lighting retrofit and upgrade was completed in 2013. The majority of the gallery spaces are lit with PAR 30 LED spotlights and pot lights. The offices and basement hallways and vaults are mainly 4' 32W T8 fixtures and LED PAR 30 and MR16 spotlights. Most spaces have motion sensors which are currently set at 30 minute delay. Staff is currently optimizing the location of sensors in some galleries and reviewing the possibility of reducing the delay. Only a few T12 lights remain and are discussed in the lighting section of this report.

3. Current Energy Performance

3.1. Site Energy Pricing

Historical billing data, from January 2012 to March 2014, was furnished by Museum London from London Hydro, London District Energy, and Union Gas for electricity, district steam and natural gas respectively. The following section outlines the historical energy use and energy costs for the sources mentioned above.

Cost of Energy:

Electricity:
- Fixed Monthly Charge: $239.65
- Current Consumption Charge: $.1009/kWh
- Peak Monthly Demand $6.48/kW

District Purchased Steam:

Thermal Energy Cost (varies with energy prices on the spot market):
- 2012 Average = $8.43/Mlbs
- 2013 Average = $10.53/Mlbs

Capacity Charge (varies with the consumer price index):
- 2012 Average = $6.82/Mlbs
- 2013 Average = $6.06/Mlbs

Natural Gas:
- Consumption $0.24/$m^3$
- Fixed Monthly Charge: $21/month

Summary of Energy Bills:

The Museum paid a total of $345,000 in 2012 and $420,000 in 2013 for electricity, purchased steam and natural gas combined. This translates to an increase of approximately 21.6% from 2012 to 2013. Water was an additional fee of $20,000 for 2012 and approximately $25,000 for 2013. Part of this increase can be explained by increases in energy pricing (see discussion below) and part by increases in energy consumption (discussed in subsequent sections). Table 4 below summarizes the Museum annual costs by energy type and the division is shown in Figure 1.

Year	Electricity	District Steam	Natural Gas	Total	Water
2012	$250,237	$94,387	$915	$345,539	$19,970
2013	$302,760	$116,154	$1,368	$420,282	$24,705
Change	21.0%	23.1%	50.0%	21.6%	23.7%

Table 4: Total Energy Costs by Year

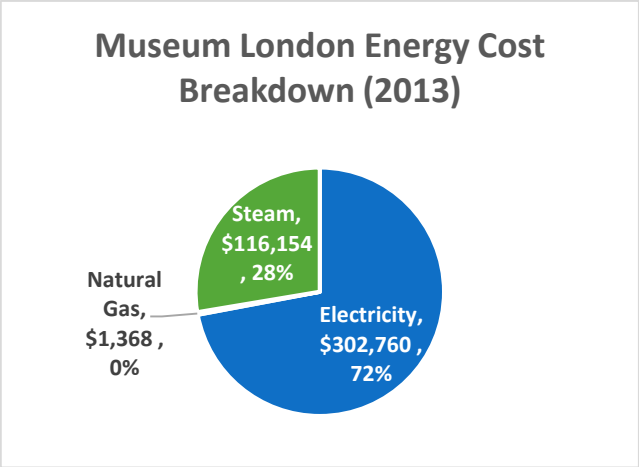


Figure 1: Total Energy Cost 2013 Broken Down by Source

Electricity costs are expected to increase over 20%, or roughly 4% per year, over the next five years according to Ontario's Long Term Energy Plan report published in 2013. This further supports the need to carefully manage electricity use. Natural gas prices, although relatively low compared to historical averages, have begun to rise as illustrated by significant increases in spot market prices through the winter of 2013/2014. As a result, Union Gas applied to the Ontario Energy Board and was approved for a 28% increase in natural gas rates. The natural gas rate increase came into effect in April 2014 and will most likely be in place to the end of Q4, 2014.

Purchased steam from London District Energy is billed with two charges. The first is an energy charge which varies with the cost of the fuel and water costs used to make the steam. In this case, the major component is natural gas, and this is based on the spot purchasing market price. Over the 2013/2014 winter months, the natural gas spot market pricing was significantly higher than normal. The thermal energy charge for purchased steam rose to $10.53/Mlbs in 2013 from $8.43/Mlbs in 2012. The natural gas prices should level out through the remainder of the year but may show increases if reserves drop due to demand from the global economy or extended winter periods.

The second charge for purchased steam bill is called a Capacity Charge and is a maintenance fee to deliver the steam to the Museum and is based on pipe sizes and delivery distance. This charge was determined at the beginning of the contract period and increases with the consumer price index (CPI) and is therefore quite stable year to year.

3.2. End Use Breakdown

Electricity End Use Breakdown

The on-site audit of equipment inventory, energy monitoring data, drawings and staff interviews were the basis of the following breakdown. Please see figure 2 below which illustrates the electrical energy breakdown by equipment type and function. The HVAC system is the largest component and includes the air handling supply and return fans, chillers, heated and chilled water pumps. The breakdown was based on equipment in operation during the audit, and therefore is representative of a winter period breakdown. It would be expected that the HVAC consumption would be a larger factor in the summer period due to increases in chiller load.

Due to the recent retrofit, lighting is a relatively small portion of the consumption breakdown at approximately 4% and plug loads (computers, printers, coffee makers, fridges etc.) are slightly larger at 7%. The IT basement rental consumption was estimated based on a daily load of 80kW as the sub-metered data was unavailable. As the museum rents out this space, it is important to ensure that this tenant is paying for both electrical demand and consumption, and to verify that the sub-meter measures the air conditioning load as well as the server and plug loads.

Please note in the figure below, DHW is short form for Domestic Hot Water system.

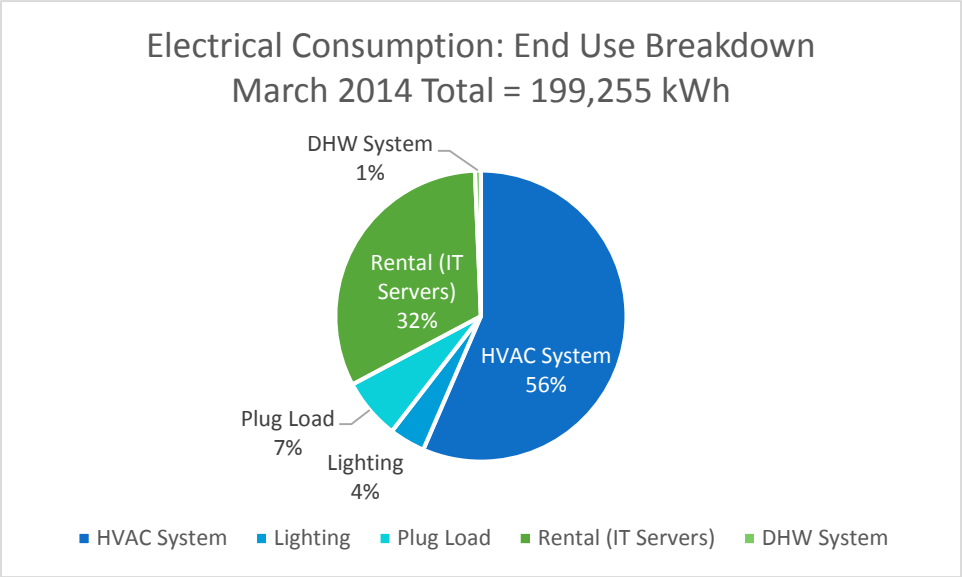


Figure 2: Electricity Consumption Breakdown by Equipment Type

3.3. Site Historical Energy Use

The historical energy consumption data from January 2012 onward was taken from utility bills furnished by the Museum Staff. The total energy use for 2012 and 2013 by energy type is shown in Table 5 and Figure 3 below.

Year	Electricity (MWh)	District Steam (Mlbs)	Natural Gas (m3)	Water (m3)
2012	2,402.6	6,198.7	2,688	9,715
2013	2,644.4	7,052.4	5,745	12,581

Table 5: Total Annual Energy Consumption by Source

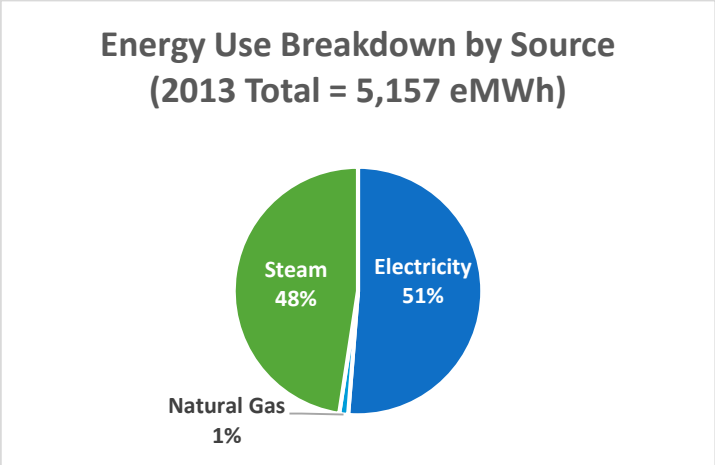


Figure 3: Total Annual Energy Consumption (eMWh) Broken Down by Source (2013)

Please note for future reference, the conversion from m^3 of natural gas and Mlbs of steam to ekWh, used throughout this report is the following:

- 1 m^3 natural gas = 37.5 MJ = 10.4 ekWh
- 1 Mlbs of steam = 1,190 MBTU = 348 kWh

It was assumed that the purchased steam was saturated, not superheated, and was shown to be provided at 118 psig according to readings furnished by the Museum.

Historical Trends in Electricity:

Electrical Consumption: The historical electrical energy consumption data from utility bills is shown in Figure 4 below.

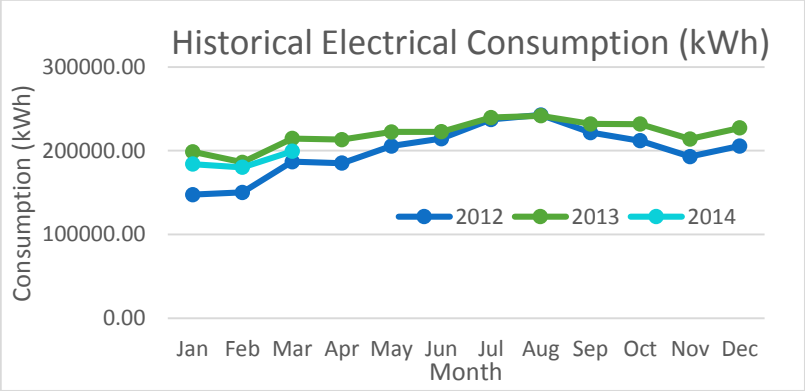
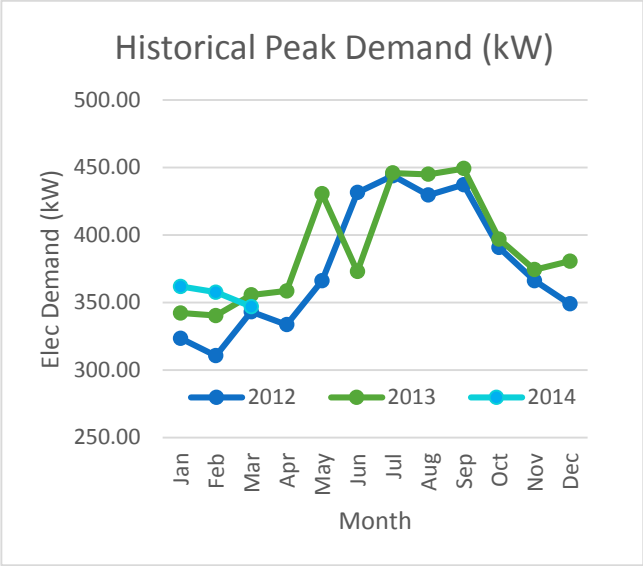


Figure 4: Historical Monthly Electricity Consumption (kWh)

The Museum electricity consumption varies significantly with cooling load and therefore would be expected to be lower in the winter and higher in the summer. Weather and base loads are discussed further in subsequent sections. The general trend on the graph above shows the July and August period to be the peak consumption months for both 2012 and 2013. It is interesting to note that the 2013 winter months were significantly higher (~60% higher in January) than the previous year. Section 3.4 will discuss the impact of weather vs. operational changes in an attempt breakdown the cause of the increase.

Electrical Demand:

Museum London is charged a monthly fee for the peak 15 minute demand registered on the hydro meter each month. It is therefore important understand the trends in monthly / hourly demand to see if there are opportunities to reduce the peaks.



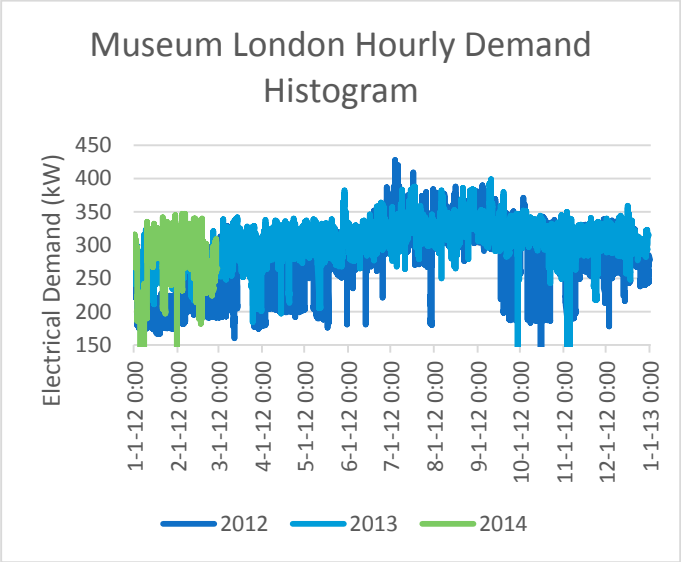


Figure 5: Historical Electric Peak Demand (Monthly) and Hourly Demand

Figure 5 above illustrates peak electrical load by month over a two year period starting in January 2012. The demand clearly increases in the summer period due to increases in cooling load. Please note the demand peak for May of 2013 vs. May 2012 (approximately 65kW difference). Although the audit team is not able to determine the reason for this peak, it should be noted that it represents approximately $420 upcharge on the May 2013 London Hydro utility bill.

A load duration curve, created from hourly demand data provided by the London Hydro, is shown below. Load duration curves help to see if there are opportunities to target short intervals with very high loads in order to lower the electricity demand charges. For Museum London, It reveals that the top loads occurred for less than 2% of the time (see the left hand side of the curve). For every 50kW in peak demand saved, the electricity bill will be reduced by approximately $350/month. There are no unusual trends on this chart as it is relatively flat and smooth.

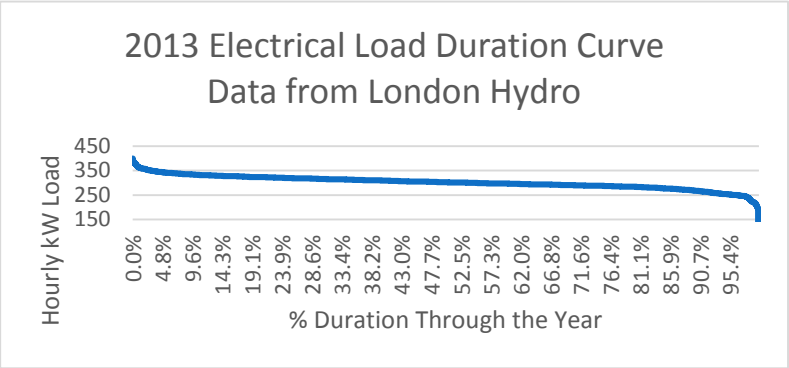


Figure 6: 2013 Load Duration Curve

Figure 7 below shows the weekly demand in July 2012 and 2013. One can see the peaks that correspond to increase in weekday periods in which office equipment and the restaurant is used. Friday seems to be lower than the rest of the week, more like Saturday and Sunday. This could be due to summer holiday schedules in which employees are often off work on Fridays.

The nighttime periods drop back to only 260 kW due presumably to chillers that continue working through the night along with the IT servers in the rental space. This indicates a potentially significant opportunity as the nighttime demand levels are higher than anticipated. Free nighttime cooling is discussed further in section 4.2 found later in the report.

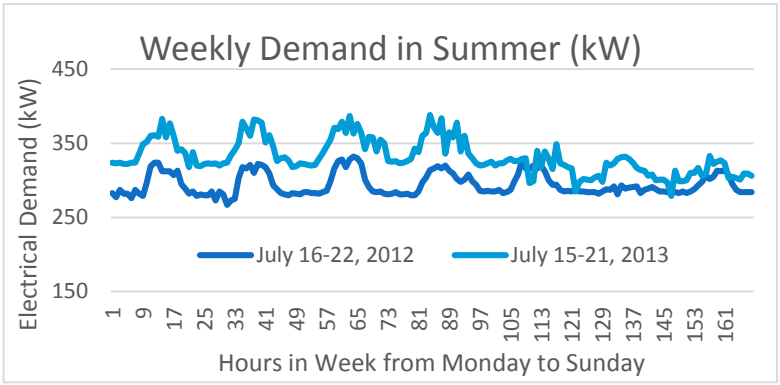


Figure 7: Weekly Demand in the Summer

Electrical Power Factor:

Power factor is a calculated value which compares the measured real power or kW load, drawn by the facility, to kVa which is a measure of apparent power. Differences in real and apparent power (measured by volt amps) occur because of inefficiencies in electrical transmission through specific systems in the facility. If the power factor drops below 0.9, the utility companies charge an adjustment fee.

Before capacitors were installed at the beginning of this year, the power factor for the Museum was below 0.9. This is now well above 0.9 every month and now no longer causing extra charges from London Hydro.

Purchased Steam:

The historical steam consumption is shown in figure 8 below. This data was collected from London District Energy utility bills from January 2012 onward. Steam consumption varies significantly with weather therefore no conclusions can be drawn from this chart without weather analysis. Please see section 3.3 for a detailed breakdown of steam usage. Please note that the February 2014 Steam data was unavailable and therefore shown as zero on the graph below.

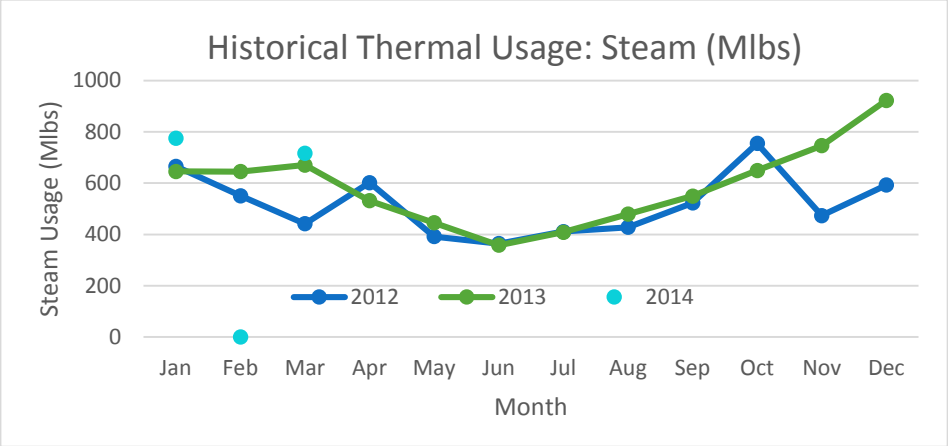


Figure 8: Historical Purchased Steam Consumption

Natural Gas:

The historical natural gas consumption is shown in figure 9 below. This data was collected from Union Gas Energy utility bills from January 2012 onward. Natural gas is only used in the Rhinocerous Room Restaurant and therefore is not a significant energy use compared to electricity and steam. It should be noted that the total natural gas use is lower in 2012 vs 2013 in part due to the restaurant being closed for the first few months of 2012.

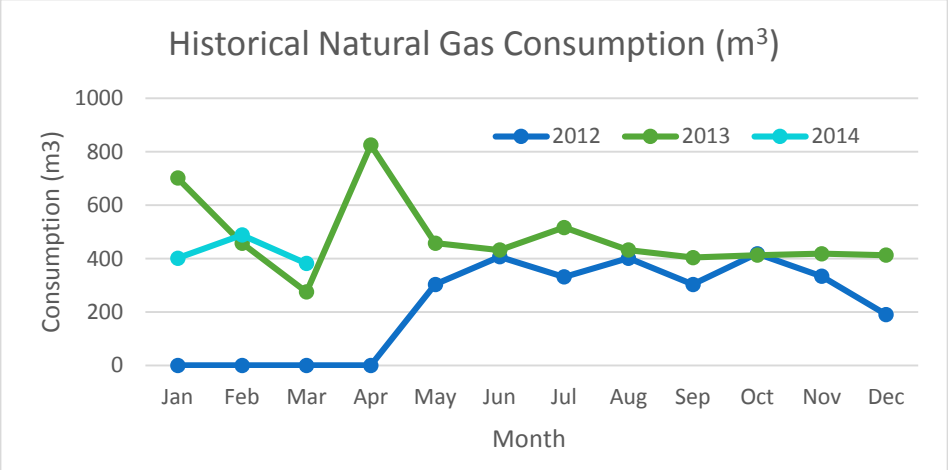


Figure 9: Historical Natural Gas Consumption

Water:

The historical water consumption data is graphed in figure 10 below. This data was collected from London Hydro utility bills from January 2012 onward. Water consumption throughout the facility is quite low. Peaks in November 2012 and June to August 2013 are over double the usage (2000 – 2500m^3 compared to approximately 1000m^3) than the average. Water consumption can go up in the summer months due to outdoor irrigation needs. It would be worthwhile to check sprinkler systems to ensure that there are no leaks and that the timers are functioning properly. The peak shown in November 2012 is unexplained but could be due to a number of reasons including a significant flush of the hydronic heating system, or a water leak that was fixed quickly. Museum facility staff should review the log books to try and pinpoint this issue.

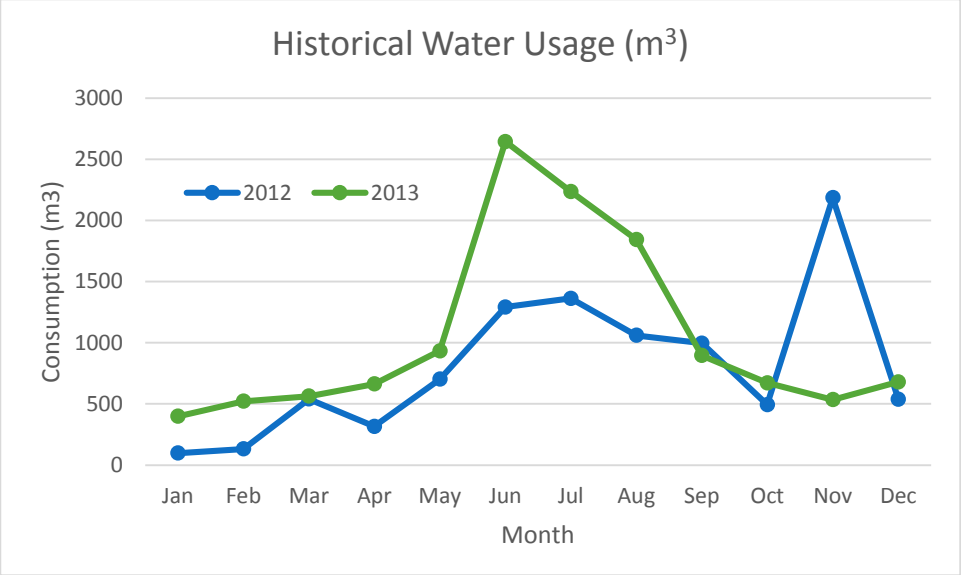


Figure 10: Historical Water Consumption

3.4. Energy Baseline Analysis

When reviewing energy consumption and efficiency for a particular facility, management is usually interested in several key points.

- the ability to evaluate or predict future trends in energy use
- determine the base load of electricity and/or steam which is due to non-weather (heat, cool, humidify) dependent energy use
- to determine the degree of dependence between electricity/steam use and weather.

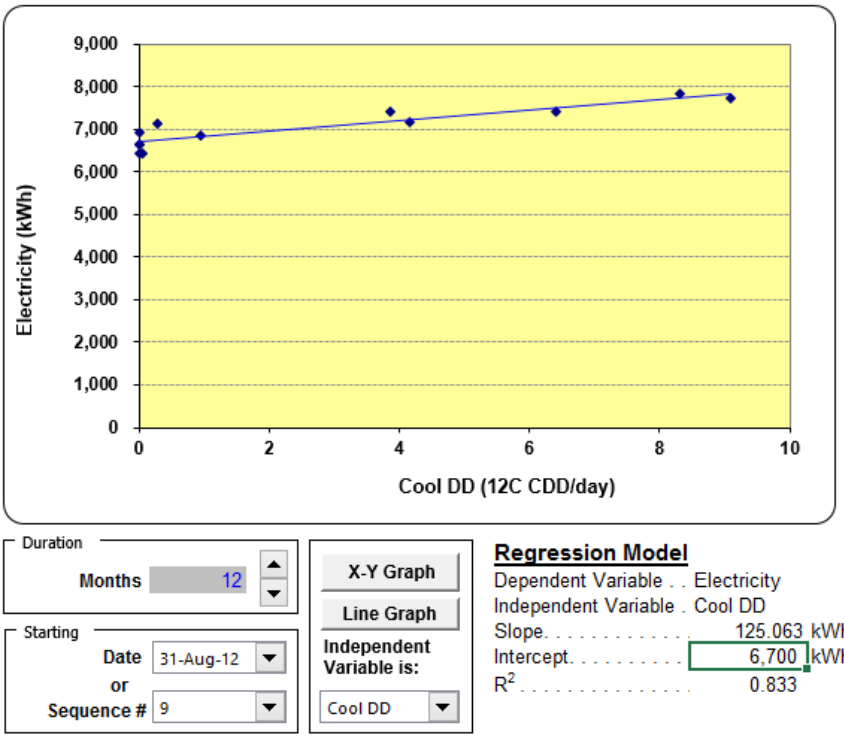
The relationship between energy consumption and weather is determined using a statistical method called regression. Without this analysis, energy use could vary from month to month, and it would not be apparent whether it was due to an operational change, a new installation of equipment or a warmer than normal winter month.

This analysis is very useful as it provides a basis from which energy project can be evaluated to determine future savings. Essentially, regression analysis attempts to measure the degree of correlation between the dependent (electricity or steam use) and independent variable (weather), to establish a predictive relationship. For this facility, the analysis was completed for both electricity and steam consumption. Weather will affect electricity consumption in the summer time and steam consumption primarily in the winter.

Electricity Analysis

The regression analysis of electricity consumption vs. weather data yielded a good correlation (coefficient R^2 = 0.833). It can be concluded therefore that the variation in electricity consumption each month is highly correlated to changes in outdoor air temperatures over the period of the analysis (August 2012 to July 2013).

Below is an illustration of the line of best fit from monthly steam consumption (Mlbs) and temperature data (Heating/Cooling Degree Day (HDD/CDD)). The HDD and CDD data was obtained from the London Airport weather station.



The linear regression yielded the following relationship:

$$Y = 125.06 x + 6,700$$

Y = daily electricity consumption (kWh)
x = Heating Degree Days (HDD) for day
Base Electricity Consumption (kWh) = 6,700 kWh/day
Heating Load Constant = 125.06

Figure 11: Linear analysis for the period of Nov. 2012 – Dec. 2013

Y represents the facility electricity consumption in kWh, and x is the total heat & cooling degree days for the day. The formula tells us that the plant requires 125.06 kWh of electricity for every heating degree day (HDD) and that the non- heating base load of the facility is approximately 6,700 kWh / day or approximately 201,000 kWh / month.

Cumulative Sum Analysis - Electricity

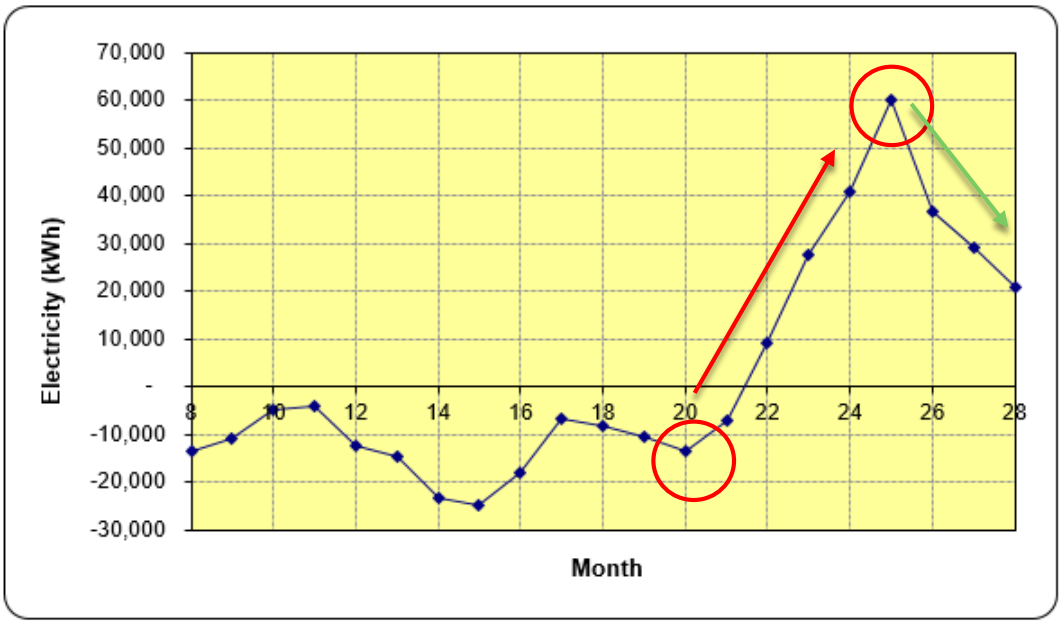
Cumulative Sum (CUSUM) analysis is a tool that uses the regression analysis above to compare current performance to previous baseline performance. It is a valuable tool to help management quantify the energy savings associated with conservation measures. It can also help to identify predictive maintenance opportunities of energy consuming equipment that often go undetected for long periods of time.

The figure 12 below illustrates the cumulative sum trend for the electricity consumption in this facility. The slope of the graph will be level if the facility is operating in the same manner as the baseline (August 2012 to July 2013). A downward trend indicates that energy consumption is improving compared to baseline (due to new equipment, procedures, preventative maintenance etc.). An upward trend indicates an increase in usage.

Reviewing the trend shown in figure 12 below, a change can be seen in the slope after point 20 and 25 (circled in red). This indicates a change in the way the building was operating which could be due to a variety of factors including the method the chillers were being operated, damaged equipment or faulty sensors. It should not be due weather related issues as this source of variation has already been removed from the analysis.

Additionally, the increase in energy use could be a caused by the rental unit server loads, and unfortunately the consumption data was not available to the auditors therefor it cannot be isolated from the main museum building electrical consumption.

The electricity consumption increase starting in August 2013 is shown to have improvement beginning in January 2014. As electricity represents the most expensive energy bill, it would be advisable for Museum staff to try and understand the causes of the two events to ensure that there are no outstanding equipment or sensor issues.



Month	Date dd-mmm-yy	Actual Electricity kWh	Cool DD 12C CDD	Baseline Predicted kWh	Difference (Act - Base) kWh	CUSUM kWh
8	31-Jul-12	237,351	347	251,096	- 13,745	- 13,745
9	31-Aug-12	242,614	258	239,941	2,674	- 11,072
10	30-Sep-12	221,753	116	215,469	6,283	- 4,788
11	31-Oct-12	211,972	30	211,426	546	- 4,243
12	30-Nov-12	192,972	2	201,237	- 8,265	- 12,508
13	31-Dec-12	205,674	-	207,699	- 2,025	- 14,533
14	31-Jan-13	198,789	-	207,699	- 8,910	- 23,443
15	28-Feb-13	186,064	-	187,600	- 1,535	- 24,979
16	31-Mar-13	214,576	-	207,699	6,877	- 18,102
17	30-Apr-13	213,269	8	202,050	11,219	- 6,883
18	31-May-13	222,518	129	223,833	- 1,314	- 8,198
19	30-Jun-13	222,687	192	225,024	- 2,337	- 10,535
20	31-Jul-13	239,719	282	242,930	- 3,211	- 13,745
21	31-Aug-13	241,710	219	235,101	6,610	- 7,136
22	30-Sep-13	232,004	118	215,769	16,235	9,099
23	31-Oct-13	231,824	44	213,252	18,572	27,671
24	30-Nov-13	213,952	0	201,024	12,927	40,598
25	31-Dec-13	227,289	-	207,699	19,589	60,187
26	31-Jan-14	184,106	-	207,699	- 23,593	36,594
27	28-Feb-14	180,139	-	187,600	- 7,461	29,133
28	31-Mar-14	199,255	-	207,699	- 8,444	20,689

Figure 12: Cumulative Sum analysis for Electricity Consumption

Purchased Steam Analysis

The regression analysis of steam consumption to weather data yielded a strong correlation coefficient (R^2 = 0.920). It can be concluded therefore that the variation in steam consumption each month is highly correlated

to changes in outdoor air temperatures (and the resulting humidity changes), over the period of the analysis (August 2012 to July 2013).

Below is an illustration of the line of best fit from monthly steam consumption (Mlbs) and temperature data (Heating/Cooling Degree Day (HDD/CDD)).

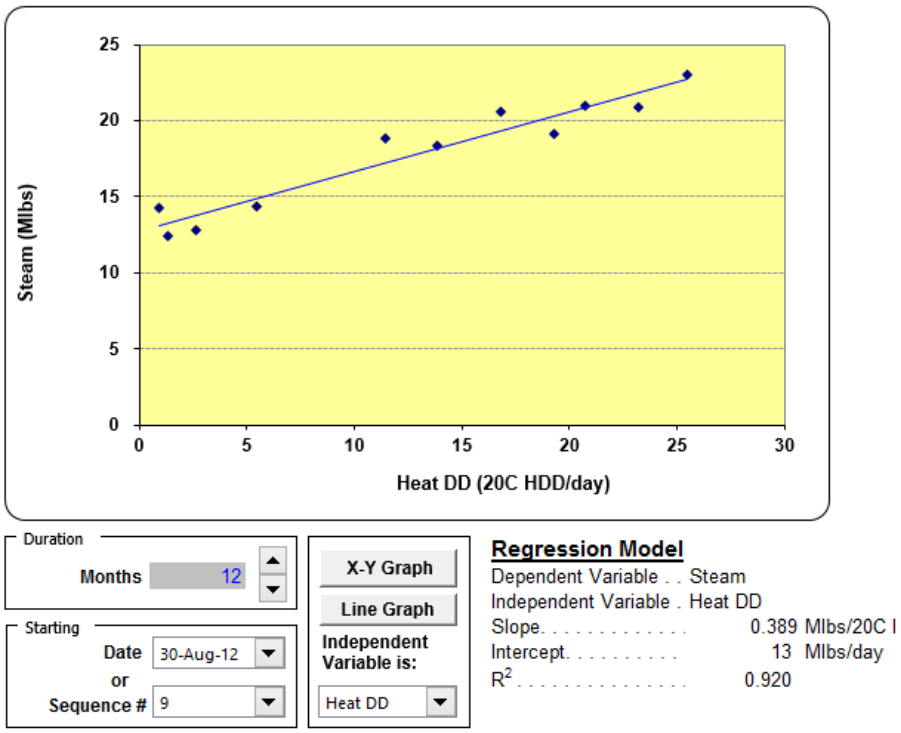


Figure 13: Linear analysis for the period starting February 2012 to December 2013

The linear regression yielded the following relationship:

Y = 0.389 x + 13 (formula for line shown in Figure 13)

Y = daily steam consumption (Mlbs)
x = Heating Degree Days (HDD) for the day
Base Steam Consumption = 13 Mlbs / day
Heating Load Constant = 0.389

Figure 14: Linear analysis for the period of February 2012 to December 2013

This formula can be used in the future to predict expected energy use by plugging in the actual heating degree days (HDD) and then comparing it to the actual measured consumption at the utility meter. Y represents the facility steam consumption in Mlbs, and x is the total heating degree days every day. This formula can be used for monthly calculations by using the monthly degree days for 'x' and multiplying the intercept '13' by the number of days in the month.

The base load for the facility is shown at the intercept of the 'Y' axis and zero Heating DD. The base load of 13 Mlbs/day (approximately 390 Mlb/month) is not weather sensitive and probably indicates the steam used to heat the domestic hot water tanks, as well as any constant base humidification.

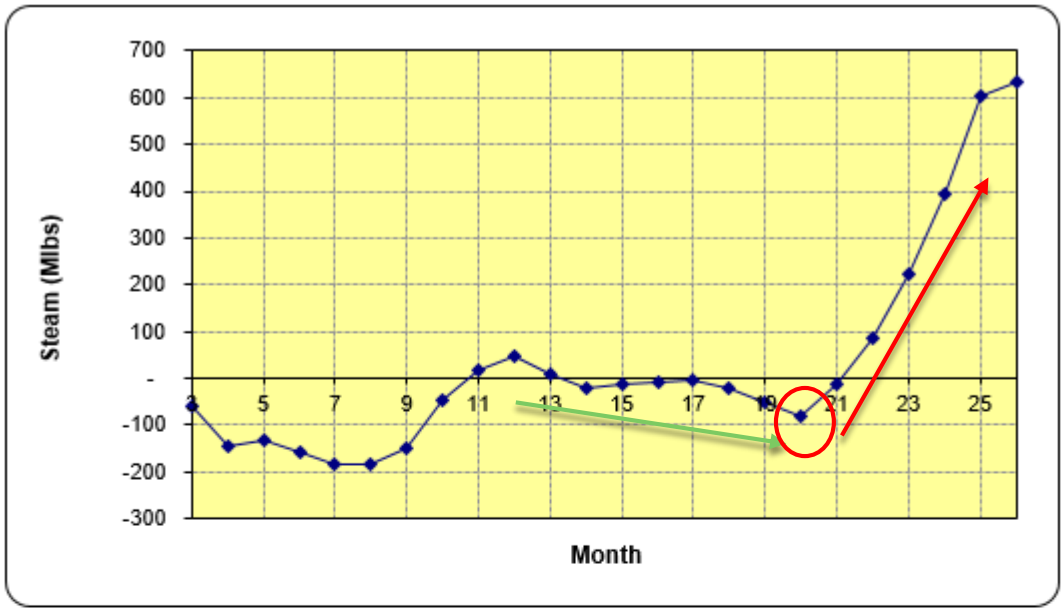
Please note a heating balance point temperature of 20C, and a cooling balance point temperature of 18C was used in the analysis. The weather data was from the London, Ontario Airport weather station.

Cumulative Sum Analysis - Steam

Cumulative Sum (CUSUM) analysis, as discussed in the electrical section above, is a tool that uses the regression analysis to compare current performance to previous baseline performance

Figure 15 below illustrate the cumulative sum analysis for the steam use in this facility. The slope of the graph will be level if the facility is operating in the same manner as the baseline (August 2012 to July 2013). A downward trend indicates that energy consumption is improving compared to baseline (due to new equipment, procedures, preventative maintenance etc.). An upward trend indicates an increase in usage.

Reviewing the steam analysis below, shows that a change occurred after point 20 (in August 2013) which is circled in red, causing steam consumption to go up dramatically compared to the baseline. This trend could, for example, indicate fouling in the hydronic heat exchanger. As steam represents a large portion of the overall energy bill, it is important for the Museum to determine the cause of the increase to ensure that any outstanding facility issues have been addressed.



Month	Date dd-mmm-yy	Actual Steam Mlbs	Heat DD 20C HDD	Baseline Predicted Mlbs	Difference (Act - Base) Mlbs	CUSUM Mlbs
3	29-Feb-12	551	611	609	- 58	- 58
4	30-Mar-12	442	374	529	- 88	- 145
5	02-May-12	602	426	588	14	- 131
6	31-May-12	392	118	417	- 25	- 156
7	29-Jun-12	365	55	392	- 28	- 183
8	31-Jul-12	411	2	410	1	- 183
9	30-Aug-12	428	29	395	33	- 149
10	28-Sep-12	523	130	422	101	- 48
11	07-Nov-12	755	457	689	65	17
12	30-Nov-12	474	387	445	29	45
13	31-Dec-12	593	598	629	- 36	9
14	31-Jan-13	646	719	676	- 31	- 22
15	28-Feb-13	645	713	635	10	- 12
16	01-Apr-13	670	664	668	3	- 9
17	30-Apr-13	532	402	527	5	- 5
18	31-May-13	446	170	462	- 17	- 22
19	28-Jun-13	358	75	387	- 29	- 50
20	31-Jul-13	409	45	440	- 31	- 81
21	30-Aug-13	479	66	409	70	- 11
22	30-Sep-13	550	145	453	97	86
23	31-Oct-13	649	298	512	137	223
24	29-Nov-13	746	531	577	169	392
25	31-Dec-13	923	777	712	211	603
26	31-Jan-14	775	890	743	32	635

Figure 15: Cumulative Sum Analysis for the period of February 2012 to December 2013

4. Energy Conservation Measures

4.1. Heating Ventilation and Air Conditioning

4.1.1. Verify Proper Operation of All Air Dampers

It is important that all air handling dampers are operating correctly in order for the HVAC control system to work in an efficient and consistent manner. The position of the air dampers compared to the control set-point should be verified to make sure they are actually in the desired position. Poorly aligned dampers can cause excess outdoor air to be allowed into the spaces increasing the heating, cooling and humidification loads and increasing variation in temperature and humidity.

During the audit, it was observed that the outdoor air flow to Air Handling Unit 5 (A05) was only 49 CFM according to the onsite meter. The space currently requires significantly higher levels of outdoor air to meet ASHRAE 62-2010 requirements (approximately 1,500 CFM) and therefore the air damper position may need to be checked. It may be also advisable to regularly check and/or recalibrate the air flow meter to ensure that the airflow rates are accurate.

Damper positions can be checked by having an operator send a control signal to open and close the dampers, and then visually check that they are fully open or fully closed. To check if dampers are modulating correctly, also check the 50% position.

4.1.2. Repair Outdoor Air Humidity Sensor (Enthalpy Control of the Economizer)

It was noted by Museum staff that enthalpy controls on the economizer are not working because the outdoor humidity sensor has failed. This is not uncommon and it should be noted that humidity meters not only fail, but often do not provide adequate accuracy[1]. This meter will need to be replaced in order to fully utilize the damper setback positions when outdoor conditions change. In addition to replacing the humidity sensor, the outdoor temperature sensor should also be checked for accuracy. A weather station grade unit is recommended due to its increased accuracy as well as proper shielding from snow, rain, wind and other elements.

The cost of a humidity sensor is dependent on the desired accuracy. For Museum London, we recommend a higher degree of accuracy and therefor a sensor accurate to +/- 2% would cost $275 (not installed). For reference a lower accuracy humidity transmitter (+/- 3%) would cost only $169. Please see Appendix C for a suggested transmitter, equipment specifications. We estimate that the total installed cost would be $400 and although difficult to calculate exactly, the device would easily pay for itself in under one year.

Once the new sensor is installed, the controls will need to be checked to ensure proper damper positions based on outdoor air conditions (temperatures / humidity). Without this system working properly, the HVAC units will not be able to take advantage of free cooling from cool nighttime outdoor air in the summer or free daytime cooling if required in the winter (instead of using the chillers).

[1] 'Issues with Economizer Control'; Steven Taylor PE, ASHRAE Journal, November 2010

4.1.3. Demand Controlled Ventilation for Upper Gallery

The day of the audit, air handling systems A01 to 5 were delivering a total volume of approximately 7,600 CFM of outdoor air (based on site meters) to the spaces. By ASHRAE 62-2010 standards, the spaces served by these units only require approximately 5,000 CFM of outdoor air (0.06 CFM/ft^2, 7.5 CFM/person). Some spaces may be under-ventilated (see section 4.1.1 re: system A05). The top floor of the gallery however, served by AO1 and AO2, was over ventilated by approximately 2,700 CFM and 1,600 CFM of outdoor air, respectively. This presents a significant opportunity for energy savings because of the additional energy required to condition outdoor air to the setpoints within the facility.

The audit team was also informed that some of the upper gallery spaces are rented on occasion for weddings and special events. As such, the outdoor air requirements and the need for heating, cooling and dehumidification, will vary greatly based on use. It is therefore recommended that the outdoor air be controlled by the demand requirements of the space. This is made possible by retrofitting the space with CO_2 sensors to allow for demand controlled ventilation. CO_2 levels in the air vary with occupancy and will adjust outdoor air when measured CO_2 levels change during use.

In addition to reducing outdoor air to minimum levels during occupied hours (when special events are not taking place), building controls can be programed to close the fresh air dampers completely during off hours to further increase energy savings in the winter months.

The calculated annual energy savings for demand controlled ventilation for the upper galleries (A01 and A02) is 1310 GJ from the combination of heating and cooling savings (1020.9 Mlbs of Steam and 7210 kWh of electricity). This translates to a utility cost savings of over $17,500 / year. The cost of this project is estimated to be approximately $4,000, for two installed sensors, system integration and tuning. Please refer to Appendix C for a budget quotation (which includes cost of hardware and installation not integration and tuning). This translates to a simple rate of return for this project of less than one year and is therefore a very attractive project.

Incentives

OPA's saveONenergy program will be able to provide funding towards the execution of this project however there would need to be detailed measurement of energy use before and after the changes. Up to 50% of the project cost could be covered which is approximately $2000.

Additional Considerations

The audit team recommends that the sensors be mounted in the gallery spaces not the return air ducts as this will give a much better indication of occupancy rates. Typically one sensor would be required every 5,000ft^2 (and therefore four (4) for the second floor galleries), however a quotation from a contractor suggested only two sensors were required. One sensor would be mounted in the space used by the special events (served by A02) and a second in the spaces served by A01. The cost of additional sensors is minimal (see Appendix C) to install, and their signal could be combined with the original two sensors such that additional wiring to the basement Mechanical room would not be required.

A reputable mechanical firm with experience installing and integrating CO_2 sensors would be required to ensure that the sensors are located in the correct places in the space. The pricing includes hardware and installation including wiring from the sensors down to the BAS system located in the basement mechanical

room. The cost could be reduced significantly if wireless transmitters were possible using a BACnet or internet base system.

It was mentioned by London engineering staff that the control of humidity levels in the upper galleries is difficult when the space is rented out for special events. When large number of patrons enter the space quickly, humidity levels will go up and the current system of mechanical chilling and increased outdoor air and air exchanges are not sufficient. A recent mechanical ducting report (see Appendix A) furnished by London City staff details that air handling unit 2 (AO2) that serves the upper rented galleries, also conditions several of the basement vaults. This is a significant concern for Museum staff as humidity levels have been measured at above 60% during rental events.

Mechanical chilling is an effective way of removing humidity when the RH is higher than 50% and temperatures are high. Our team however recommends considering a desiccant dehumidifier to be used in tandem with the existing cooling coils for increased de-humidification. Desiccant dehumidifiers can work well with mechanical chilling and is preferable when thermal energy is cheaper than electrical energy as is the case for Museum London. The size of the de-humidifier will have to be determined after the Museum decides its course of action regarding demand controlled ventilation and supply fan variable frequency drives (VFD) (see section 5.0). As such we will not include specifications or pricing. Below please find a diagram of a typical desiccant dehumidifier wheel installed in a large air handling unit.

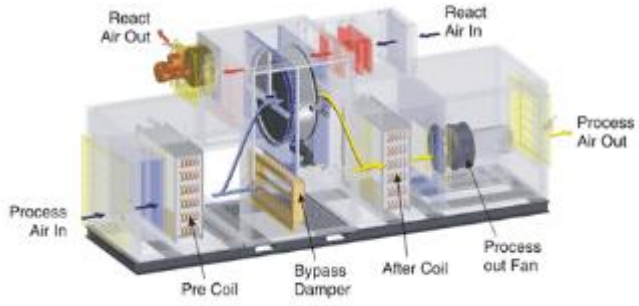


Figure 16: Illustration of a typical installed Desiccant De-humidifier Unit

Depending on how the steam is shut off to the humidifiers when it is not required, extra humidity may be being introduced into the spaces through the valve leaks when it is not called for, causing humidity variation. It may be worthwhile to verify that all shutoff valves are seating properly.

4.1.4. Condition Check of Heating and Cooling Coils and AHU Filters

During the audit it was noted that the pressure drop across the filter bank on air handling unit 2 (AO2) was 3.4"H_20 compared to the other air handling units which ranged from 0.4" to 0.6"H_20. This indicates the fillers on this unit may be clogged and need to be changed. Dirty filters increase the static pressure across the filter bank and coil, increasing fan system energy use significantly.

The condition of the cooling coils are also important for proper operation. If the coils are dirty the heat transfer coefficient of the coil will be reduced, forcing the system to move more air over the coil for the same cooling load.

It is suggested that filter and coil inspection should be added to a regular preventative maintenance program, if not already part.

4.1.5. Electric Space Heaters

Replace all plug-in electric resistance heaters with electric under desk panel radiant heaters. Two electric units were being used the day the energy audit was conducted and others were observed in the office area. Staff mentioned that the heaters are used in both the summer and the winter and it is the experience of the audit team that units are often left on by staff overnight.

Figure 17: Under Desk Radiant Space Heater

It is recommended that the electric resistance space heaters be replace with radiant panel heaters which use between 40 and 170W. This means that the units could use under 10% of the electricity used by common electric heaters which are rated 1,200W to 1,500W. The under desk radiant heating units cost approximately $100 each and conservatively will save $325 to $810 a year each in electricity consumption and demand charges. Incentives from the OPA's saveONenergy program would be available for 50% of the project cost or approximately $50/heater or $100 total for the two noted units.

Please find a specification sheet for radiant under desk heaters in Appendix C.

4.1.6. Run Ceiling Fans in Main Storage Vault

Temperature stratification occurs naturally in rooms with high ceilings as hot air rises and cool drops to the floor. Stratification takes place in the main basement storage room (room number 54) which is why ceiling fans have been installed. The space is approximately 12,500 ft^2 (not including the mezzanine area) with 20 foot high ceilings. Conditioned air is introduced at the ceiling and returned at the floor level through the HVAC system return air ducts, creating air movement, however some heat will accumulate at the ceiling.

It is recommended that the nine existing ceiling fans be run continuously during the winter heating months. This will help to de-stratify the air, creating a warmer temperature at floor level resulting in lower heating demand heat from the duct heaters and two hydronic ceiling mounted unit heaters. The five duct heaters are electric and are therefore quite expensive to operate compared to the other heating sources.

Every degree of temperature (deg.C) savings from air de-stratification will typically result in 3-4% energy reduction in HVAC for the space. Although savings are difficult to quantify as each space is unique, one could expect over a 5-10°C temperature gradient from the floor to ceiling. Mixing fans could allow the capture of half of this lost heat reducing the heating load by 5°C or approximately 15% reduction in HVAC energy consumption for the room. Considering a 4 month period over the winter months, it is estimated the de-stratification fans will save conservatively between $900 and $1200 every year.

Ceiling fan motors typically use 0.1 kW of electrical demand to operate (the unit specified in Appendix C uses 0.081 kW). Running the nine fans every day would use approximately 2,419 kWh of electricity (allowing for four winter months and operating continuously). At a cost of $0.10/kWh this translates to $244/year in additional electricity costs. The overall project energy savings would therefore be $950/yr.

The audit team also observed the fans were not in operation and when turned on, several bearings sounded "noisy". Several of the ceiling fans require servicing or possibly replacement. The installed cost per new Energy Star rated ceiling fan is estimated at $500 (please see Appendix C for a typical replacement unit). This translates to a total cost of $2,000 if four fans need replacing. The project would therefore provide a simple payback of 2.1 years.

We recommend initially servicing the existing ceiling fans and monitoring their performance over the winter months before purchasing new replacements.

Incentives:
It may be worthwhile to investigate a different kind of de-stratification fan than the existing models. Fans with very large blade diameters work best with a low speed motor. Up to $1350 per unit is available in incentives from the OPA saveONenergy program for fans with a minimum blade diameter of 20'. A minimum ceiling height of 25' with forced air handling system is required to be eligible for this grant. An example is shown in the attached link: https://www.uniongas.com/business/save-money-and-energy/space-heating-programs#DestratificationFans

4.1.7. Review of Chiller Performance and Operation

During the audit, the Museum facility manager discussed the summer operation of chillers 1 and 2. Currently one chiller operates continuously (lead chiller) and the second (lag) operates if the cooling demand increases above the capacity of the lead chiller. The supervisor added that Trane was reviewing the option of running both chillers at 60% load instead of the current lead/lag system.

We have reviewed the efficiency of the chillers at full and part load. At full load the power consumption is 0.727kW/Ton. This compares to 0.55kW/Ton at part load. Initially it appears that operating two chillers at part load would not be advisable from an energy perspective as it may consume more power per Ton of cooling. We would suggest discussing this in more detail with Trane, however in the short term, we recommend maintaining the existing lead/lag system.

4.2. Controls

4.2.1. Seasonal Humidification and Temperature Setbacks

According to recent discussions regarding ASHRAE Class A status for museums (see reference email in Appendix B), Museum London is considering seasonal temperature and humidity setbacks as a means of reducing energy consumption. According to the ASHRAE guidelines for "A" Class Control, short term fluctuations of +/-5% RH and +/-2degC, with a seasonal temperature change of up 5C and down 10C and a seasonal humidity change of up 10% RH and down 10% RH would be acceptable in certain circumstances (depending on the exhibits in house).

To quantify this opportunity, the savings has been calculated if the facility dropped the RH set point gradually from 50% in the summer to 40% in the winter. This would be achieved through the building automation

system and building operator adjustment so no capital cost would be incurred. Assuming present outdoor air rates, a humidifier efficiency of 80%, and the new set point of 40% RH holding for three months over the winter, the requirement for steam for humidification would drop by approximately 140 Mlbs of Steam and a modest amount of chilling reduction which translates to approximately $2400 / year.

Reduction the humidity set point in the winter will also reduce the amount of condensation forming on colder surfaces like outside doors and windows. This may help protect the collection from mold damage.

In addition to humidity setbacks, the guideline allows some setback for temperature as well. Any museum space that stores artefacts and is not open to the public, could be set at a much cooler temperature during the winter months (the vaults, main storage room etc). As mentioned previously in this report, a 3-4% reduction in HVAC consumption can be expected in each space for every 1deg.C of setback. Although up to 10degC is allowed, even a 2degC setback can achieve significant savings.

It is recommended that the Museum implement a protocol to take advantage of the seasonal temperature and humidity setbacks beginning this fall.

4.2.2. Lower Set Point Temperature in Loading dock area

The loading dock is used several times a day and often the loading door is left open to accommodate trucks too long for the bay. This caused the loading area to experience large swings in temperature based on the current outdoor air temperature (even when it is very hot or cold). Several alternatives were reviewed to attempt to deal with the infiltration however none were cost effective (please see section 4.4.4).

As this is a working area that has no permanent employees or office space, it is recommended that the two hydronic unit heaters be set at 16C (60F) instead of the current 20C. For every 1C of setback, one can expect between 3-4% HVAC savings for the space in question.

4.2.3. Temperature Resets (to reduce over cooling or heating)

The supply air temperature set point is 16°C in the winter time. Due to heat introduced by the humidifiers (see section 4.3.4) as well as daytime plug loads, staff and zone reheat the return air can be quite warm. When mixed with outdoor air, it can often be higher than the 16°C set point forcing the chillers to be engaged. Temperature resets work by resetting the supply air temperature to a higher value (often to the lowest zone set point) to avoid unnecessary chilling. This can significantly lower energy consumption by not only lowering the cooling load, but also helping to avoid unnecessary reheating in the zones which can waste energy. The temperature resets would be programed into the BAS system and would work automatically.

4.3. Steam System

4.3.1. Energy Recovery from Steam System Condensate

The auditors observed that all the condensate formed in the short absorption manifolds and from the hydronic steam high efficiency exchanger is routed directly to the sewer. A thermograph indicated the temperature of the condensate is approximately 80C. The condensate flow based on a thermal balance of the steam system is approximately 3 gpm. The direct discharge of hot condensate therefore represents a loss of potentially 150,000 Btu/hr of sensible heat.

We investigated the installation of a helical heat exchanger designed to recover some of this valuable energy. We estimate that a small helical exchanger could be installed in the existing condensate discharge line. A slipstream from the domestic hot water return line would be connected to the heat exchanger thus pre-heating the return water prior to entering the domestic hot water tank. This initiative could significantly reduce the required steam load for heated water coils required to heat the domestic hot water system. We have calculated the heat recovery to be 130,000 Btu/hr (equivalent to 38kW). This is equivalent to approximately $18,000 of steam if it was completely captured and reused.
Blue Sky has received a quote from Graham Exchanger (see Appendix C) to provide a small, spiral exchanger to recover the waste heat from the condensate. The cost of the exchanger is $8,131 and the total estimated installed cost is $17,000.

The savings will be from steam because the DHW is primarily heated by a process hot water coil in the main tank. The heat recovery of 130,000 Btu/hr (38kW) shown above would more than cover all DHW heating needs. Approximately 95 Mlbs Steam/year is required for DHW heating (based on ASHRAE average usage per person and assuming 200 visitors a day for 3hrs each, an average of 25 staff members each day and assuming the Steam/Heating water exchanger is approximately 70% efficient).

At a value of $16.59/Mlb of steam, the savings of 95 Mlbs of Steam would be approximately $1,550/year. This gives the project a simple rate of return of approximately 11 years. Due to the long payback period, we recommend continuing research to find heat exchange methods that are less expensive in order to reduce the payback to under 5 years.

If this project was installed to preheat DHW, approximately $16,500 of wasted heat would still be available for use in other systems. It is therefore additionally recommended that the Museum look for other places the heat could be used to improve the effectiveness of the recovery project. It is important to recognize that this is an attractive opportunity because once a system is installed, the captured free heat from condensate will be available for many years and savings will continue to accumulate over the full life cycle of the equipment.

4.3.2. Monitor performance of steam hot water exchanger

There is a lack of local instrumentation on the hydronic steam high efficiency exchanger. These exchangers are prone to fouling because of the narrow tubes and space between the shell and tubes. We suggest local temperature and pressure indicators be installed on the hot water inlet and outlet (steam pressure is available). By trending the temperature and pressure profile any fouling issues can be identified and remedied.

The estimated cost of installing local temperature and pressure gauges is $1,000. This compares to a total value of $116,000 of steam used by the heat exchanger in 2013. The additional monitoring would need to save less than 1% of the total annual steam consumption to pay for the installation.

We observed in the CUSUM analysis for steam consumption (see section 3.0) that from September 1st, 2013 to January 31st, 2014 the steam use was consistently higher than the predicted baseline. This could be indicative of fouling in the hydronic steam exchanger. We recommend installing the local instrumentation to assist in the detection of exchanger fouling.

4.3.3. Fix Steam Leaks (Short Absorption Manifold in Air Handling Unit)

The auditors observed that steam is leaking from the Nortec short absorption manifold (SAM) between the steam header and the steam tubes. Silicone rubber gaskets can be used to provide an effective seal between the header and the tubes. Blue Sky understands that the manufacturer (Nortec) has recommended replacement of the gaskets. We endorse this recommendation. Preventing steam leaks will save steam consumption and help alleviate overheating of the supply air.

We have estimated the amount of steam leaking through the manifolds in AO1 and 2 to be 90lbs/hr. This accumulates to 780Mlbs/yr. If the leaks are repaired the Museum could save up to $12,800 in one year. According to the manufacturer, the gaskets should be replaced every five years.

4.3.4. Install Insulation on Short Absorption Manifold in Air Handling Unit

The museum HVAC system is controlled such that a chiller is needed to operate in the winter in order to cool the supply air. This is in part due to the humidifying steam and the steam manifold itself heating the air above the set point of 16C. The current HVAC system requires the number 3 chiller to operate during the winter to provide trim cooling. The chiller itself has four scroll compressors (15HP each) and in addition, the chilled water circulating pump (10HP) is operating. If extra heating of the supply air could be prevented, the electrical use in the winter months due to chilling could be significantly reduced.

We have reviewed two potential methods for reducing the heat input from the SAM system:

- Provide insulating stainless steel sheaths around the manifolds and tubes. This may necessitate manifold replacement. The intermediate space between the tube and sheath can be insulated.
- Use enthalpy control combined with demand controlled ventilation to lower the supply of fresh outdoor air in the winter and lowering humidification demand. This combined with a lower inside RH target in the winter (40% instead of 50%) will greatly reduce humidification needs.

The Museum will have to remove the SAM humidifiers to replace the tube to manifold gaskets (described above). This would be an ideal opportunity to replace the manifolds with the insulated tube design. Palser Enterprises Ltd. (Nortec's representative) has provided a quote for the manifold replacement (included in Appendix C). We estimate the total installed cost would be $24,000 for two manifolds (A01 and A02). If this project is combined with the gasket replacement (above) the savings will be greater than the $12,800 in leak prevention and possibly as high as an additional $12,900 if the insulated manifolds and tubes prevent heating of the supply air to the point where the chiller use was minimized. The simple rate of return would therefore be just under 2 years.

4.4. Building Envelope

4.4.1. Draft Reduction – Building Air Infiltration Reduction

There is an opportunity to reduce drafts, increase occupant comfort and improve control of humidity while reducing energy costs with the addition of weather stripping and caulking around some perimeter doors and windows. Outdoor air infiltration can increase energy costs associated with heating and cooling the building as the air is unconditioned. The uncontrolled exchange occurs through orifices (cracks, windows/frames, under doors) and through diffuse flow (through the center of materials that air can penetrate). It can have

serious consequences because infiltrated air is uncontrolled and unconditioned, therefore allowing entrain pollutants as well as affecting heat loss and gain and humidity levels.

Air leaks in the facility were found around exit doors (emergency and employee exit doors located in the office), older single pane windows and the loading dock doors. Although savings can be difficult to determine without space air pressure tests, we estimate that approximately 5% reduction in building heat loss would be achieved through improved caulking, weather stripping and window maintenance.

In addition to the areas mentioned above, ducts located in a storage room (Room 132) by the main floor workshop had unsealed sections (please see photo to right in which daylight was visible). The staff mentioned occasional mold problems on the wall near this unsealed vent. We believe that this could be contributing to the mold issue if moist air enters the space from the outside and condenses on the uninsulated brick causing moisture issues. Additionally, this type of issue can significantly impact the temperature and humidity in the space causing increases in heating and cooling. In the same location, it was noted that the walls were not insulated.

Figure 18: Unsealed Ducting Showing Light from Outside.

A full review of all outer walls, doors and windows is recommended to address air infiltration issues with additional, caulking and weather stripping.

4.4.2. High Efficiency Windows

In the Community Gallery (room 203) natural lighting is provided by a 50 foot long (5 foot high) double pane window. A section of the window is shown in Figure 19 below. The window consists of two single glazed fenestrations separated by approximately 3 inches. The outer pane is sealed with caulking and the inner panes are sliding pane arrangement and therefore are not air tight. The sliding panes enable the windows to be open so that effectively the window functions as a single pane. A thermal reading was taken on the glass surface. The glass temperature was 10C even though the room itself was 22C. This indicates that significant heat loss is occurring.

We have estimated the current heat loss through the window to be approximately 19,000 Btu/hr when the outside temperature is 7F and the indoor temperature 22C. This heat loss is reduced to approximately 2,200 Btu/hr with a tripled glazed, argon filled energy efficient window. The cold glazed surfaces are conducive to moisture formation (which was also observed during the audit). In the summer months the existing window will contribute to the cooling load by excessive heat gain. We have estimated the heat gain to be approximately 29,000Btu/hr. If the window was replaced with a triple glazed, argon filled design, the heat gain would fall to 16,000Btu/hr.

Figure 19: Bottom of 50' long window on West wall of upper gallery. Two separate single panes.

We estimate the cost of replacing the window is $15,000. It is recommended that the new window be triple gazed, argon filled with a low emissivity coating and a warm edge spacer. The cost is based on a quote from a local commercial supplier (FibreTec) and is of Class 5 accuracy (+/- 50%). A quote is attached in Appendix C.

The savings are estimated as $600 in the winter and $150 in the summer months and as such, the savings do not justify the replacement of the existing window. Once the fenestration reaches the end of its service life or if condensation issues begin to cause damages to the window frame, it should be replaced with a high energy efficiency rated unit. We suggest that the window be inspected to ensure the outer pane caulking is truly sealed and in good repair.

4.4.3. Insulated Metal Doors

The audit team observed four fire egress doors during the site visit. All of the doors exhibited condensation on the interior surface – (i.e. below the interior's ambient dew point). The egress door from the Forum Gallery is a good example of this problem (see Figure 20, below). Two recommendations would help alleviate this problem:

- Replace the weather stripping around the door to prevent cold air ingress.
- Replace the door with an insulated fire door.

Blue Sky requested quotes from ABC Fire Door of Mississauga and Republic Doors and Frames. The installed cost in both cases was approximately $1200. There is a minimal price difference ($100) for specifying an internal polyurethane insulated core which provides a "U" factor of 0.1 compared to 0.34 for a non-insulated door.

The surface area of the doors is small thus the heating/cooling load savings would be negligible. We do not recommend replacing the doors now however they should be upgraded to insulated doors when the existing doors reach the end of their service life.

It will be necessary to replace the weather stripping on all the external doors (both fire and employee exit doors) to reduce drafts (infiltration).

Figure 20: Fire Egress Door with Condensation

4.4.4. Loading Bay Door Air Curtain

The loading bay door is approximately 15 feet high and 10 feet wide. The length of the loading bay is approximately 40 feet. This means that standard tractor trailer units (trailer length alone is 48 feet) will not fit inside the loading dock and allow the access door to close. The loading dock is constantly in use with as many as 20 truck deliveries in any given week allowing outdoor air in and out of the space.

Several alternatives were reviewed below however the only cost effective option is to turn down the set point on the two hydronic unit heaters to 16C (60F). For every 1C of setback, one can expect between 3-4% HVAC savings for the space in question. During the audit, the unit heaters were set at 20C.

Figure 21: Loading bay area.

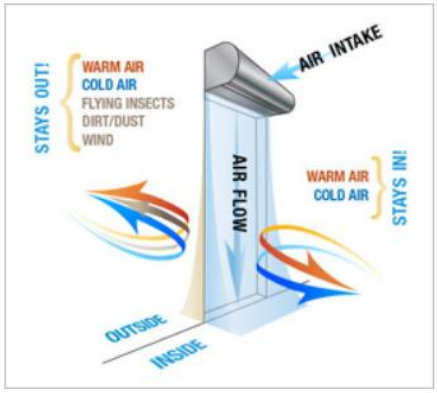


Figure 22: Typical air curtain installations

The dock area is not serviced by the Museum's HVAC system however there are two unit heaters by the access door as shown in Figure 21 above. Also visible is the fume exhaust system. The audit team noted that the heaters were running continuously and the loading bay was cold. This creates cold walls in the adjacent rooms thus raising their heating requirements.

A potential solution to this issue would be to install a horizontally mounted air curtain above the access to prevent the ingress of the external cold air (as shown in Figure 22 above). This would reduce the heating demand in the loading bay and prevent the common interior walls from becoming cold surfaces.

The cost for installing a surface mounted air curtain is $ 33,000. This estimate is based on a budget price from Biddle using their IndAC design (see quote in Appendix C). The hot water system would be extended to provide the heating medium for the air curtain. A new 600V power supply would have to be provided to the air curtain. The existing unit heaters which are currently directed towards the access door opening would be relocated and directed towards the storage area. One heater would be sufficient. The water supply for the second heater could be extended to the new air curtain. **Union Gas offers an incentive** to install air curtains, and the application is submitted before August 31st, 2014, the total incentive would be $2,250 for this air curtain.

Even with the incentive, we do not recommend this option as the cost of the air curtain is prohibitively expensive especially considering the energy savings are difficult to quantify - the heat source for the air curtain would be the same as for the existing unit heater. Requesting formal quotes would reduce the overall cost however at this stage we do not recommend this option.

As an alternative we reviewed the current arrangement of the unit heaters. The current location of the ceiling mounted unit heaters in the loading bay area is accordance with the manufacturer's recommendations i.e. directed towards the access door as indicated in Figure 23 (below) therefore we do not recommend changes to their position.

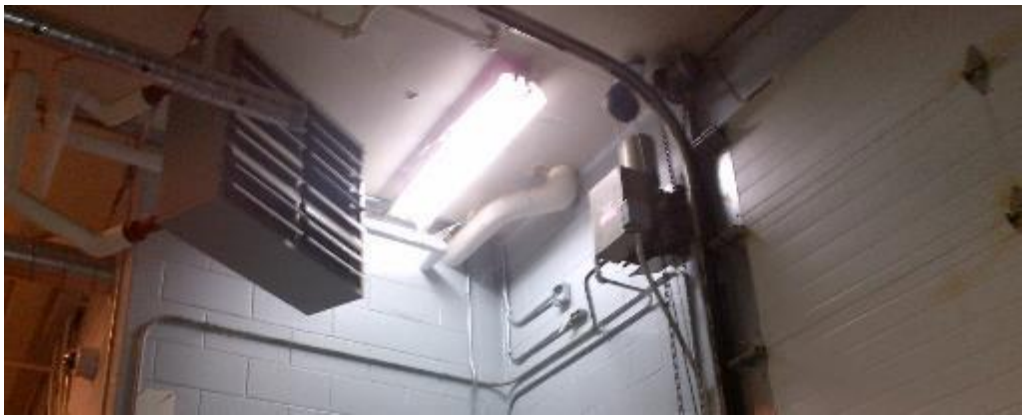


Figure 23: Close-up of unit heater in loading bay area.

4.5. Lighting

4.5.1. Higher Efficiency T8 Opportunities

The majority of the building lighting has been retrofitted and upgraded to fluorescent T8 fixtures with magnetic ballasts and LED Par and MR16 spotlights. Your current 4' T8 light fixtures use 32 watts of power for a single bulb fixture. A recommended upgrade is to an energy efficient type of T8 bulb called "Premium T8" which uses 28W of power and is longer lasting, up to 36,000 hours compared to 20,000 hours for standard T8 bulbs. Both bulbs can be used interchangeably therefore it is suggested that the current T8 bulbs be replaced with Premium T8 bulbs when they burn out throughout the facility.

Incentives:

The Premium 4' T8 bulbs area slightly more expensive (an extra $1.04/bulb), however the current incentive from the saveONenergy program of $1/bulb makes up for the difference. The overall life cycle cost is about $2.40 less per lamp each year compared to the regular 32W 4' T8s (over 10% savings) due to the energy savings and the increased life expectancy. This translates to an overall electricity savings of approximately $70/year based on 100 bulbs.

Please contact London Hydro to have this incentive preapproved and to obtain the list of approved T8 bulbs.

4.5.2. Replacement of remaining T12 bulbs with T8

Several small spaces currently still use T12 lamps and it is recommended that they be upgraded to electric ballasts and T8 lamps. T12 bulbs and ballasts are no longer being manufactured so therefore these fixtures will need to be changed in the near future as bulbs and ballasts are no longer available in the marketplace.

The electrical panel room (116A) behind the main cloak room is fitted with one, 2 lamp T12 fixture. The packing storage room (124) in the loading dock area also has two, 2 lamp 12 fixtures. The pump room (22A)

beside the Volunteer lounge has one, 2 lamp 4' T12 fixtures. All should be converted to 4' T8 bulbs with electronic ballasts.

The cost of retrofitting T12 fixtures (change ballast) to accommodate T8 bulbs is approximately $50/fixture. The total cost of retrofitting the rooms listed above would be $200. The overall electrical savings for this retrofit is fairly small at approximately $15/yr because the lights are not often used however it should be completed due to the phase out of T12 bulbs and ballasts.

Incentives:
Incentives are available from the OPA saveONenergy program, which will furnish $17/fixture to change from T12 to T8s. The incentive for this project would therefore be $51 reducing the overall cost from $200 to $149 and reducing the simple payback to just under 10 years. Please note that this item will need to be combined with other lighting projects to meet a $100 minimum per application. It will have to be submitted to London Hydro, and approved, before work is initiated, in order to be eligible for the incentive.

4.6. Domestic Hot Water System

4.6.1. Domestic Hot Water (DHW) Building Loop – off hour shutdown

Purchased city water is heated and stored in a central location in the main mechanical room. Once heated, the hot tap water is continuously pumped through the building in a loop to service the restaurants, washrooms and general sinks. A pump continues to circulate hot water throughout the day and night even when the facility is unoccupied.

Electricity can be conserved if the building recirculation line pump is placed on a timer that would have it turn on and off based on building occupancy. Annual energy savings would be $95/year based on a system shut off for five (5) hours each night. The cost of installing a timer would be approximately $200 giving the project a simple payback of 2.1 years.

Incentives:
This measure is eligible for a saveONenergy incentive which would be based on $0.10/kWh up to 50% of the cost of the project. It will have to be submitted to London Hydro, and approved, before work is initiated, in order to be eligible for the incentive.

4.7. General Mechanical and Plug Loads

4.7.1. Overnight Shut Down of Computers and Computer Power Management

An average desktop computer uses approximately 50 W of power when idle. There approximately 30 computers in use in the offices at the Museum and, although most computers may get shut down at night and on vacations, some may be left on. This results in a cost of approximately $28/computer annually. Although initially this sounds insignificant, it can add up quickly over a number of employees.

A suggested course of action could be to utilize an automatic shutdown option available within Microsoft office, or alternately to engage the IT department to develop an automated system for nighttime shutdown. There should not be a capital cost associated with this option and with an assumed 5 computers shut down by this option, $140/year can be saved in electrical consumption. Please note, the adopted approach should accommodate employees who may be working outside of normal operating hours.

In addition to automatic shutdown of all computers, each should be checked for proper power management settings. Power management is built into Microsoft Windows and can be accessed panel. Monitors should turn off after 5 to 10 minutes of inactivity and the system should go into standby mode through the operating system control after 10 to 15 minutes of inactivity.

4.7.2. Regular Cleaning of Kitchen Freezers and Refrigerator Condensers

The condensing coils on refrigerators and freezers provide heat exchange with air allowing heat to be removed from the unit. If the coils and screens become clogged or covered with dust, heat exchange reduces, causing the compressor to work harder and longer to maintain the same fridge/freezer temperature. The unit shown to the right is the top of an ice freezer located in the Rhinoceros lounge kitchen.

Dusty compressor coils on fridges and freezers will cause the compressor to run longer and therefore increase electricity consumption. The coils should be vacuumed twice a year.

Figure 24: Ice Freezer Compressor Coils in Rhinoceros Lounge Kitchen

4.7.3. Install Vending Machine Misers and De-lamp Machines

Vending machine misers can save a significant amount of energy during unoccupied hours. Also, de-lamping the vending machine advertisement lights can reduce electricity costs by approximately $50/year. All vending machines (only one drink machine noted by the auditors) should be de-lamped and have misers installed.

Incentives:

This measure is eligible for a saveONenergy incentive which would be based on $0.10/kWh up to 50% of the cost of the project. It will have to be submitted to London Hydro, and approved, before work is initiated, in order to be eligible for the incentive.

4.7.4. Replacement of Older Freezer Unit (ENERGY STAR appliances)

The majority of appliances appear to be in good working condition so upgrades to newer appliances would not be advisable until the current appliances require replacing. One exception was noted by the auditors in the second floor catering kitchen. An older model chest freezer had a significant layer of frost covering the inside surface and was essentially empty. It is used when functions held in the upper galleries require use of the catering kitchens. This appliance should be replaced with a new Energy Star rated freezer appropriately sized for the current catering requirements.

Figure 25: Chest Freezer located in Upper Gallery Catering Kitchen

Natural Resources Canada has investigated the trends regarding appliance efficiency and published detailed results which can be found at:

http://oee.nrcan.gc.ca/publications/statistics/cama08/pdf/cama08.pdf

Incentives:

This measure is eligible for a saveONenergy incentive which would be based on $0.10/kWh up to 50% of the cost of the project. It will have to be submitted to London Hydro, and approved, before work is initiated, in order to be eligible for the incentive. In addition, please be aware that saveONenergy program from the OPA sponsors a free program to pick up old refrigerators and freezers.

5. Points for Consideration

The following are opportunities which require further investigation, or do not have significant paybacks but are worthwhile energy conservation measures to consider. Often the cost of technology drops with time therefore these items may become affordable in years to come. Other projects may be worthwhile to consider once the asset is being replaced at end of life.

5.1. Review of Supply Air Rates (Upgrade to VFD)

It is outside of the audit team's expertise to advise the Museum on air exchanges as there may be exhibit specific requirements. We would however like to bring to your attention a possible significant energy conservation opportunity which would involve upgrading the current constant speed supply fan motors to variable speed motors. Reducing the supply air rate in some spaces when appropriate can significantly reduce the energy used by the fans. Installing variable speed drive units would allow the museum the flexibility to change the supply air rate for specific exhibit periods and reduce the rates in off hours to further improve savings.

This alternative provides savings in two ways:

1. Reduces wear on the motors and fans based on reduced use
2. Reduces energy use during partial load periods

The number of air exchanges in the museum from each of the main air handling unit varies from two to six air exchanges/hr. There are various reasons to design a system to replace air within a space more than 1 or 2 times an hour. In a museum, some exhibits may give off various air born contaminants or odours therefore may require additional ventilation. Some museum guidelines speak to varying the exchanges based on ceiling height.

In order to quantify this opportunity the annual energy use should be reviewed. Using A01 and A02 as an example, we can review their supply fans which are both driven by 25 hp motors and use approximately 250,000 kWh (combined) per year in electricity. This translates to over to $27,000 in consumption costs and approximately $2,900 in demand charges. If the volume of air supplied by the fan was reduced by 50% the energy used by the two fans would drop to less than 25% (engineering fan laws state that the energy should drop to 12.5% when the CFM is dropped in half but this typically is not seen in the field). The resulting energy savings would therefore be approximately $22,000 annually (using current energy pricing).

This particular example would require VFDs to be installed on the two supply fans (S1 and S2) as well as return fan 2 (RF2) to ensure that the air is properly balanced in the space. Additional engineering work would be required to determine the physical configuration of the VFD installation which can be installed on belt driven fans. A general feasibility grade estimate to purchase and install three VFDs for supply fans S1 and S2 as well as return fan R1 would be approximately $22,500 for the equipment and another $17,500 for the installation (~$40,000 total) which translates to a simple payback of 1.8 years.

Incentives:
Incentives for variable frequency drives (VFDs) are available from London Hydro through OPA's saveONenergy program. We recommend following the 'engineered track' of the saveONenergy program which allows an incentive based on $0.10 per kWh of annual electricity saved up to 50% of the project cost (capped at 1yr payback). In this example, the incentive would be likely capped at $18,000 and this attractive grant would reduce the simple payback to 1 year. A less complicated application is available through a 'prescriptive' program but the incentives are not as high.

5.2. Outdoor Dew Point Sensors

As an upgrade, to improve humidity control of the building systems, the audit team recommends the Museum review the possibility of installing dew-point sensor (with temperature measurement) for economizer control, instead of the traditional enthalpy control (using a humidity and temperature sensor). Traditional enthalpy or temperature controlled economizers can introduce excessive moisture into the building. This typically happens in the evenings, night and morning hours when outside temperature is low but moisture remains high. A dew point sensor would measure water content and would allow the economizer to be set so that it never uses outdoor air with a higher dew point than the level desired (50%RH). Measuring and controlling to dew-point instead of humidity can give a higher degree of control.

5.3. Formal Preventative Maintenance Program

As the control of the building becomes more complex, it becomes increasingly important for the instruments and system to be both accurate and reliable. If not already set up, a formal preventative maintenance program would be advisable for the primary HVAC equipment to minimize the likelihood of failures and ensure that control systems are working properly at all times. Significant operating and energy costs can be saved through regular and rigorous rounds Conversely, savings due to energy conservation projects can be lost if the systems are not maintained.

The Museum should consider setting up a formal preventative maintenance program for the HVAC system in this facility if not already set up. If it is already in place, consider adding all HVAC local and remote sensors and meters.

5.4. Roof insulation

It was brought to our attention that the Museum London will be replacing the roof next year. This is a terrific opportunity to assess and improve the insulation on the roof as it is quite expensive to add otherwise. Unfortunately the audit team did not have access to the current roof construction but it is recommended that the highest affordable R-value be purchased. As hot air typically sits at the top of rooms near the ceiling, heat loss can be much higher through the roof than other envelope surfaces.

It is suggested that the thermal breaks be inspected around the skylights when the roof is replaced. Considerable heat is lost through window frames if they are not properly sealed, insulated and fitted with thermal breaks preventing the transfer of heat energy. It may be also advisable to decide whether the skylights should be removed altogether if they are not in use.

6. Next Steps

A number of energy conservation opportunities have been identified at Museum London which will not only lower the cost of operating the building but may provide a better conditioned working environment for staff and visitors. According to Ontario's 2013 Long Term Energy Plan, the cost of electricity will continue to rise over the next few years. It will therefore become increasingly important to address energy efficiency opportunities as they are identified to capture cost savings.

It is a requirement that the Museum London apply for pre-approval for incentive funding (through the utilities) for all projects before work is carried out. In addition, it is recommended that the building HVAC system be re-commissioned and set up with a preventative maintenance program to ensure that the systems can maintain the savings from any executed energy conservation project.

Information regarding the OPA saveONenergy Incentive Funding can be found at the following three locations. Blue Sky Energy Engineering and Consulting would be pleased to help fill in the applications for incentives requested by the Museum.

OPA saveONenergy website:
https://saveonenergy.ca/Business/Program-Overviews.aspx

London Hydro:
https://www.londonhydro.com/site/#!/energy_conservation/content?page=landing

Union Gas:
https://www.uniongas.com/business/save-money-and-energy

End of Report.

APPENDIX A:

Reference Email: ASHRAE 'Class A' Control Guidelines

From: "Meehan, Brian" <bmeehan@museumlondon.ca>
Sent: Thursday, March 20, 2014 5:22 PM
To: "Mercer, Cydna" <cmercer@museumlondon.ca>, "andrea@bskyeng.com" <andrea@bskyeng.com>
Subject: RE: London Museum: Missing Energy bills

Hi Andrea,

As requested, below is an email exchange which will give you a sense of where we are going in terms of environmental controls.

Please let me know if you have any questions.

Thanks.

Brian

Hi all,

I just spoke with Simon Lambert**,** Preservation Development Advisor at the Canadian Conservation Institute about our environmental guidelines and he informed me that as a Category "A" designated institution within the Movable Cultural Property program, our facility is expected to meet the requirements of ASHRAE "A" Class of Control wherever Certified Cultural Property is stored, displayed and transits through.

These guidelines are outlined here: http://www.cci-icc.gc.ca/caringfor-prendresoindes/articles/enviro/controls-niveaux-eng.aspx and I've copied the relevant section below as well.

He noted that there are two options for the "A" Class of Control; one with a seasonal setback, and one with no seasonal setback. **He recommended that we look at the seasonal setback option as this allows for the greatest flexibility and greatest possibility of energy savings while still meeting guideline targets**. He did indicate that this is a relaxation of what CCI has traditionally asked for from Class A museums.

He also indicated that we'd still be expected to override these guidelines in the case of an institution (such as the National Gallery of Canada) asking for tighter controls as it is the lender's prerogative.

Simon would be happy to talk more about this should you have further questions, or require clarification. His contact information is below.

Please let me know if this provides the direction you need.

Thanks.

Brian

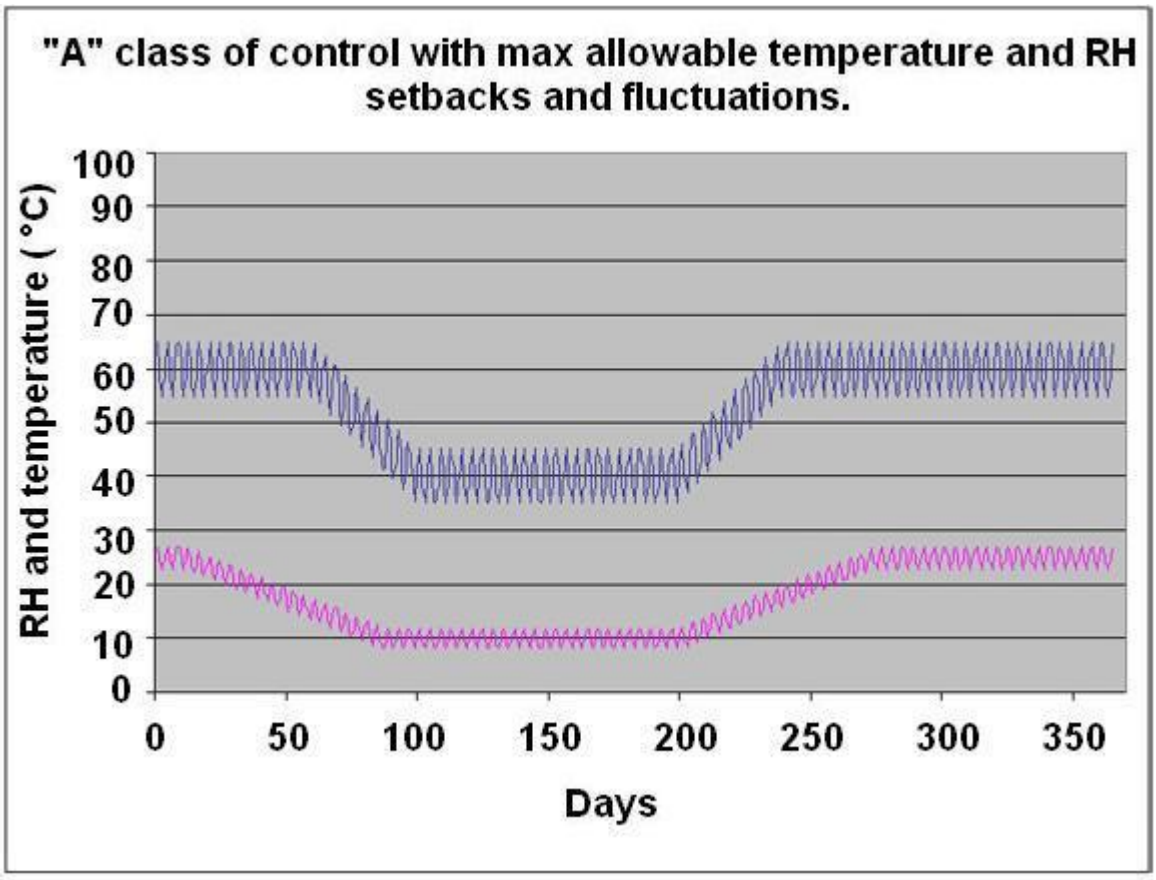
"A" CLASS OF CONTROL (good control, some gradients or seasonal changes, but not both)

This degree of control has two subcategories:

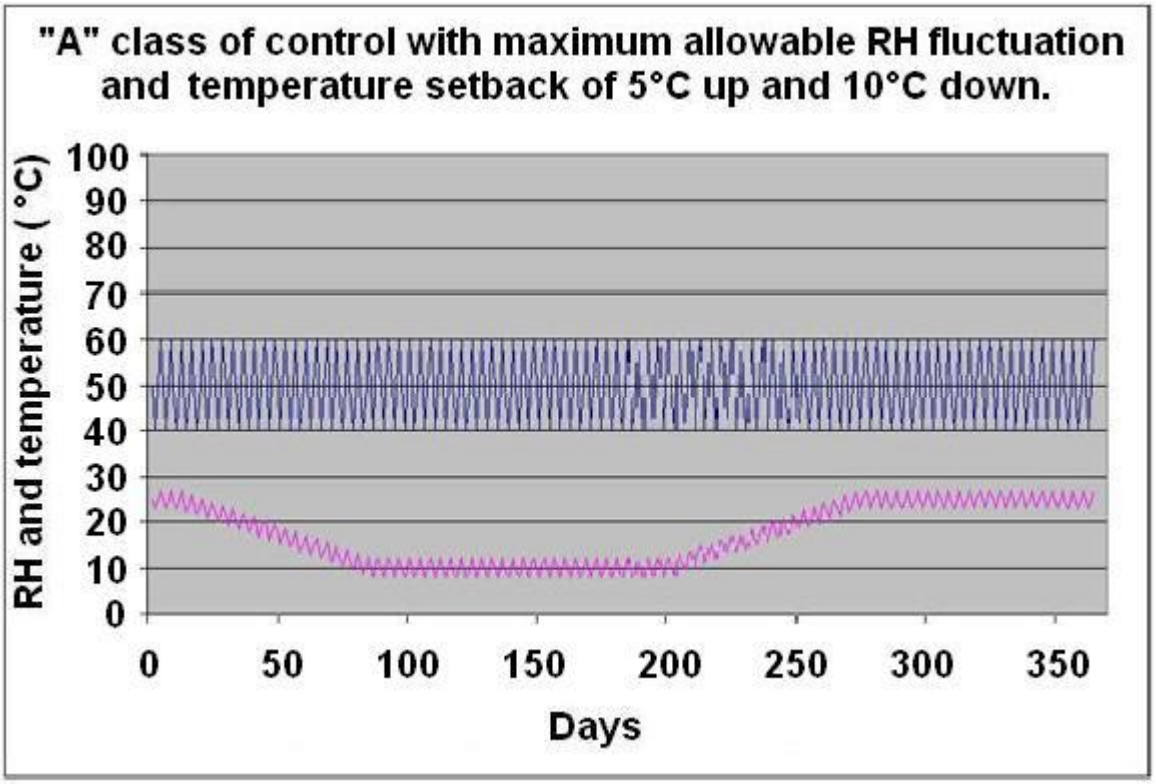
- short-term fluctuations of ±5% RH and ±2°C, with a seasonal temperature change of up 5°C and down 10°C, and a seasonal humidity change of up 10% RH and down 10% RH

- short-term fluctuations of ±10% RH and ±2°C, with a seasonal temperature change of up 5°C and down 10°C

The images below show the worst case scenario with maximal permissible fluctuation.



Graph 3: The relative humidity is ramped down during the fall period from a summer level of 60% to a winter level of 40%, and then ramped up again in the spring. These changes are gradual over a period of a couple of months, rather than abrupt. The temperature is ramped down during the summer and fall period from a summer level of 25°C to a winter level of 10°C, and then ramped up again in the spring. These changes are gradual over a period of 3 months, rather than abrupt.



Graph 4: The Relative Humidity is constant at 40% to 60% on a daily basis. The temperature is ramped down during the summer and fall period from a summer level of 25°C to a winter level of 10°C, and then ramped up again in the spring. These changes are gradual over a period of 3 months, rather than abrupt.

Collection risks and benefits

Small risk of mechanical damage to high vulnerability artifacts; no mechanical risk to most artifacts, paintings, photographs, and books. Chemically unstable objects will become unusable within decades.

Comments

The letter "A" was assigned to this specification because it was felt to be the most cost-effective degree of control for most collections, given the ability and mandate to provide a climate-controlled building. Such systems will probably operate within AA levels most of the time. To stay reliably within A conditions year-round is a resource-intensive task in most climates. The larger seasonal adjustments in set points are a recognition that even major museums must face energy and sustainability constraints, and that these suggested temperature changes are not a significant risk.

From: simon.lambert@pch.gc.ca [mailto:simon.lambert@pch.gc.ca]
Sent: Tuesday, February 18, 2014 2:44 PM

To: Meehan, Brian
Subject: Environmental guidelines, HVAC, etc.

Dear Brian Meehan,

Your question about HVAC systems and guidelines was sent to me. As a Category "A" designated institution (since 1979) within the Movable Cultural Property program, your facility is expected to meet the requirements of ASHRAE "A" Class of Control wherever Certified Cultural Property is stored, displayed and transits through. For information about what this means, please see these guidelines: http://www.cci-icc.gc.ca/caringfor-prendresoindes/articles/enviro/controls-niveaux-eng.aspx

Note that there are two options for the "A" Class of Control; one with a seasonal setback, and one with no seasonal setback. Should you have further questions, or require clarification, please do not hesitate to get in touch with me.

Kindest regards,

Simon Lambert
Preservation Development Advisor | Conseiller en développement de la préservation
Preservation Services | Services de préservation
Canadian Conservation Institute | Institut canadien de conservation
Department of Canadian Heritage | Ministère du Patrimoine canadien
1030 Innes Road | 1030 chemin Innes
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simon.lambert@pch.gc.ca
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Facsimile | Télécopieur 1 (613) 998-4721
Government of Canada | Gouvernement du Canada

APPENDIX B:

Summary Report of HVAC Zones from Mechanical Contractor

LONDON REGIONAL ART GALLERY

ROOM #	SUPPLY FAN	RETURN FAN
004	SF-5	RF-3
007	SF-5	RF-3
010	SF-5	RF-3
014	SF-5	RF-3
018	SF-5	RF-3
009	SF-3	No Return
020	SF-2	RF-2
025	SF-2	RF-2
026	SF-2	RF-2
028	SF-2	RF-2
030	SF-2	RF-2
024	SF-3	No Return
M054	SF-5	RF-3
M053A	SF-5	RF-3
110	SF-3	RF-1
111A	SF-3	RF-1
111	SF-3	RF-1
104	SF-3	RF-1
112	SF-3	RF-2
115	SF-3	No Return
113	SF-3	RF-2
120	SF-4	RF-3
120A/B	SF-4	RF-3 Thru120
114	SF-3	RF-2

LONDON REGIONAL ART GALLERY

ROOM #	SUPPLY FAN	RETURN FAN
116	No Supply	RF-1
103	No Supply	RF-1
202	SF-2	RF-1
203	SF-2	RF-1
204	SF-2	RF-1
205	SF-2	RF-1
206	SF-1	RF-1
207	SF-1	RF-1
210	SF-1	RF-1
201	SF-1	RF-1

APPENDIX C:

Recommended Equipment Specification Sheets and Quotations

Self Calibrating - CO_2 Transmitters

With BACnet® or LonMark® Certified Communicating Options

Wall Mount
TR9290

Wall Mount
TR9294

In-Duct Mount
TR9291

Splash Resistant
Wall Mount
TR9293

Aspiration Duct Probe
TR9292

A No Calibration CO_2 Transmitter

The TR9290 family of sensors are quality-engineered CO_2 transmitter targeted at applications where a dependable CO_2 sensor is required that never needs calibration.

Key features of these CO_2 transmitters include:

- ❑ Internal self-calibration method based on background measurement that also eliminates need for outdoor CO_2 sensor.
- ❑ Choice of outputs: 0-10V, 0-5V or 4-20mA and LonWorks®.
- ❑ Built to ISO 9001 standards
- ❑ Mounting options include wall, duct and in-duct.
- ❑ Utilizes a proven infrared measurement technology with over 18 years of flawless operating history.
- ❑ Supported by a team of knowledgeable application specialists. We are just a phone call away if you have questions.
- ❑ LonMark® Certified output option.

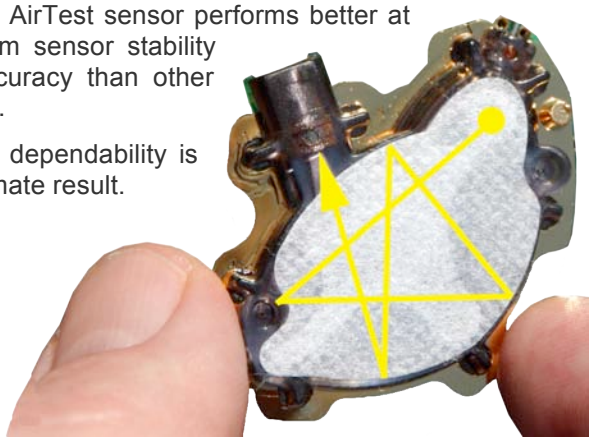
AirTest also offers CO_2 sensors that feature self-calibrating dual beam technology, and that integrate CO_2 temperature and humidity in one device. We also have a wide variety of other sensors to measure combustible and toxic gases, humidity, dew point and air velocity. Contact us for more information.

Length Does Matter…

The AirTest CO_2 transmitter has proven itself to be the most trouble free CO_2 product available today. A important reason for this is the unique, patented, oval design of the sensor. All competitive sensors use a straight path of infrared energy shining through an air sample to measure CO_2. The amount of gas that can be sampled, called the "path length" is limited by the size constraints of their wall-mounted and duct-mounted cases.

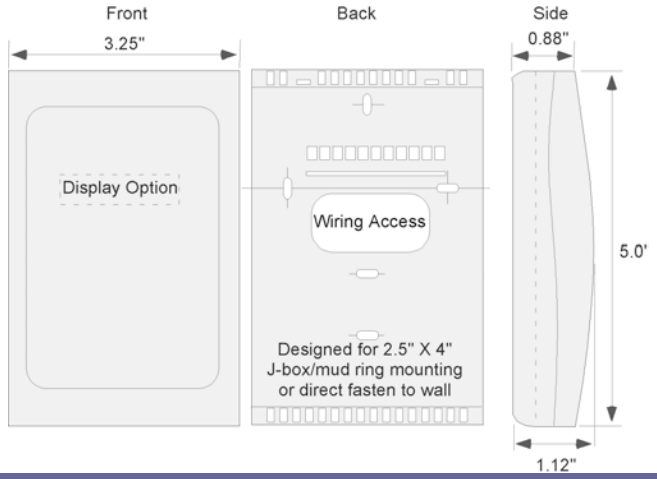
The AirTest design, using a similar sized case, provides over double the path length of any other CO_2 sensor (4.8") by bouncing the light around the small oval sensor element. Longer path length means that a larger sample of air is measured. In technical terms this results in an increased signal-to-noise ratio. This means that the AirTest sensor performs better at long-term sensor stability and accuracy than other devices.

Greater dependability is the ultimate result.

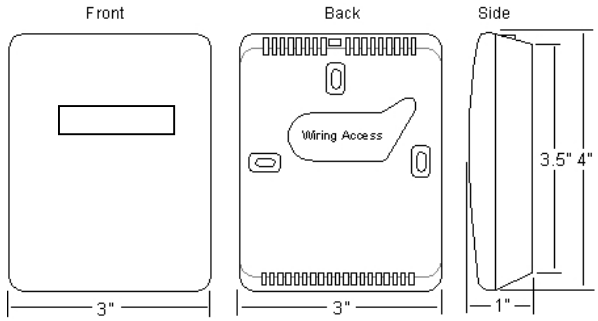


AirTest Technologies Inc. *• #9-1520 Cliveden Ave, Delta BC Canada V3M 6J8 • P: 604 517-3888 • 888 855-8880 • F 604 517-3900*
www.AirTestTechnologies.com

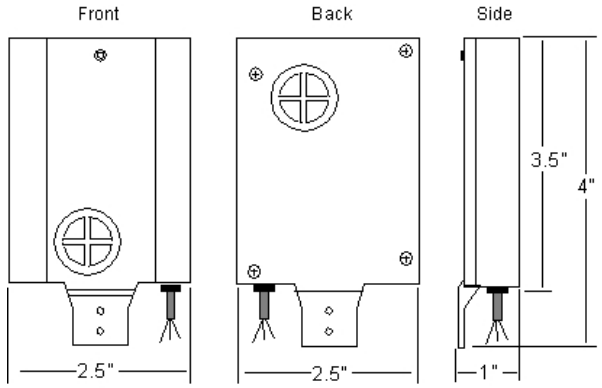
Dimensions TR9294 (New Wall Mount)



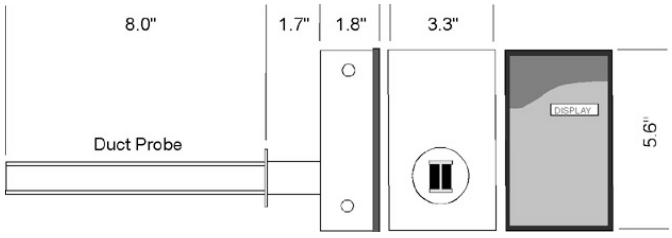
Dimensions: TR-9290 (Wall)



Dimensions: TR-9291 (In-Duct)



Dimesions: TR9292 (Aspiration Duct Probe)



Distributed By:

Specifications

General

CO_2 Detection Method: Gold Plated Non-Dispersive Infrared Optical Sensor with Automatic Baseline Correction for Self-Calibration, 4.8" optical path length, diffusion sampling.

Certification: CE, EMC89/336/EEC, CA Energy Commission, NYSERDA, LonMark® Certified (V3.4).

Transmitter Rated Life: minimum 15 years

Operating Conditions: 32 to 122º F (0 to 50ºC), 0 to 95% RH

Storage Conditions: -40 to 158º F (-40 to 70º C)

Performance

CO_2 Measurement Range: 0-2000 ppm (factory adjustable to 10,000 ppm upon request),

CO_2 Accuracy: +/- 1% of measurement range +/- 3% of measured value.

Calibration: Self Calibrating, Calibration Not Required

Response Time: T90 = <2 minutes (diffusion), < 15 seconds for flow through.

Power

Input: 24 VAC/VDC ±20%, 50-60 hz (half-wave rectified)

Average Power Consumption: ≤< 1 Watt average

Ground: Analog output transmitters must share common ground with control system.

Outputs

Linear Analog Output: Two simultaneous dual output options available: A) 0-5V & 4-20mA, B) 0-10V & 4-20mA.

LonWorks®: CO_2 ppm & % SNVT (See LonWorks® Specification on next page). LonMark® Certified.

More Information: www.airtest.com/net/Lon.pdf

BACnet® MS/TP:

User Interface: Simple DIP Switch Selection

Output To Host Control: RS485 BACnet® MS/TP

Baud Rates: 9.6K, 19.2K, 38.4K, 57.6K, 76.8K

More Information: www.airtest.com/net/BACnet.pdf

Model Number		Output	Display
TR9290	- Wall (EU-3.5' x 3")	**A** - 0-5V, 4-20mA	_ - No Display
TR9291	- In Duct	**B** - 0-10V, 4-20mA	**L** - Display[2]
TR9292	- Duct Probe	**Lon** - LonWorks®[1]	
TR9293	- Splash Resistant	**BAC** - BACnet MS/TP[1]	
TR9294	- Wall (US-3.25 x 5")		

Notes: 1 - Only available on TR9294
2 -Not Available On TR9291

Covered By US Patents: 6194735, 6016203, other patents pending

AirTest™ Technologies Inc. specializes in the application of cost effective, state-of-the-art air monitoring technology to ensure the comfort, security, health and energy efficiency of buildings.

AirTest™ Sensors That Make Buildings Smart!

1/13/12

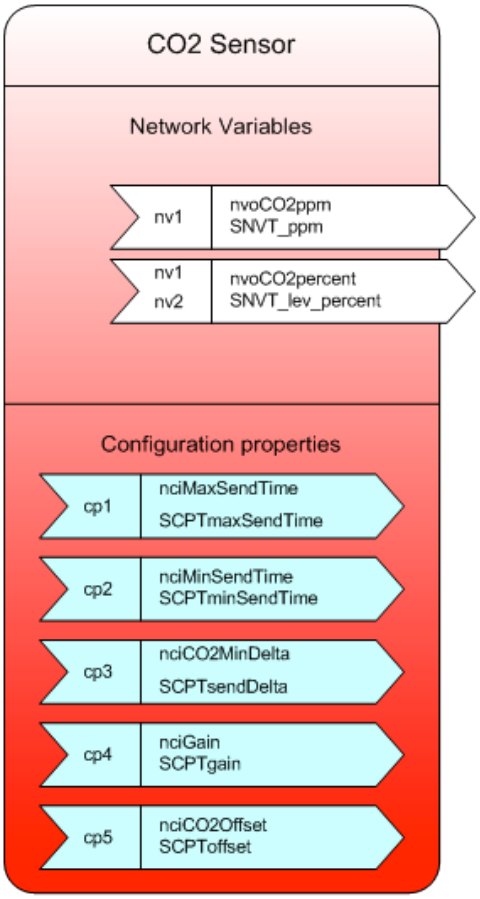
AirTest LonWorks® Specifications

Description: This LonWorks® output is only available for the AirTest Model TR9294 wall Mount CO_2 Transmitter. These sensors are all self-calibrating and will not require any maintenance for the life for the sensor (typically 15 years). These sensors provide a CO_2 ppm & % SNVT for 0-2000 ppm CO_2. Other ranges up to 0-10,000 can be factory set.

TR9294-Lon *TR9294-L-Lon*

LonMark® Specification:

AirTest Models:	TR9294-L-Lon, TR9294-Lon,
Category:	Sensor
Measurement Range:	0-2000 ppm (factory adjustable to 10,000 ppm)
Standard Program ID:	80:00:E5:0A:46:06:04:01
LonMark® Version:	3.4
Manufacturer ID:	229
Device Class:	CO_2 Sensor (10.70)
Usage:	06 – Residential/Commercial
XIF/DRF Download:	www.airtest.ca/support/sw/AirTestLon.zip
Transceiver:	04-TPFT-10
Model:	1
XIF Available:	True
DRF available:	True
LonMark Objects:	0000 Node object (1), 1070 CO_2 Sensor (1)
Clock Rate:	10 MHz
Power Requirement:	18-30VAC/VDC (1/2 wave rectified) < 1 W average
Object Details:	See diagram



3.4

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www.AirTestTechnologies.com

AirTest CO_2 BACnet® Specifications

Description:

This BacNet® output is only available for the AirTest Model TR9294 wall Mount CO_2 Transmitter. These sensors are all self-calibrating and will not require any maintenance for the life for the sensor (typically 15 years). These sensors provide a CO_2 ppm output object for 0-2000 ppm CO_2. Evaluated by the BACnet® Interoperability Testing Service (BITS), BACnet® Testing Laboratory (BTL) Certification in progress.

TR9294-?-BAC TR9294-?-L-BAC

TR9294-BAC Overview

The BACnet® objects associated with the TR9294 permits display of current values of the CO_2 transmitter. The BACnet® objects associated with the TR9294 are described below.

BACnet® Device Object

The device object allows the configuration of the TR9294. Object properties can be specified as follows.

BACnet® Device Object	Description
TR9294	This allows the operator to specify the following: Device name Device location Time and Date Universal Time Coordinates Offset APDU properties MS/TP properties Object Identifer

Other BACnet® Objects

BACnet® Objects	Default Present-Value	Range	Description
Analog Input Objects			
CO2 Level (AI1)	Display Only	NA	Displays present CO2 value
Temperature (AI2)	Display Only	NA	Displays present temperature value
Analog Value Objects			
None			
Binary Input Objects			
Pushbutton ID,(BI1)	Inactive	Active/Inactive	Pushbutton on sensor module to facilitate identifying and locating
Sensor Error (BI2)	Active	Active/Inactive	Output from raw sensor indicating an error condition
Binary Output Objects			
Remote Calibration Request (BO1)	Inactive	Active/Inactive	optional remote calibration request
ID LED (BO2)	Inactive	Active/Inactive	LED for ID purpose

1/13/12

SANDCASTLE
Energy Systems Alliance

May 20, 2014

Blue Sky Energy Engineering & Consulting Inc.

Attn: Andrea Dwight P. Eng

Quote #4065

Re: London Museum, 421 Ridout Street North, London, Ontario

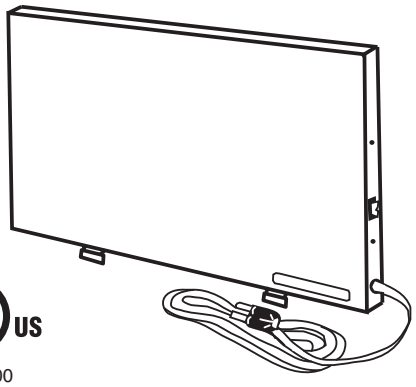
To supply and install CO2 sensors on the second floor of the above listed location, and wire to the existing BAS located in the lower level, to control dampers on two air handlers.

2	CO2 sensors TR9294-BL	$180.50/ea	$ 361.00
11	Electrician	$ 82.00/hr	$ 902.00
11	Apprentice Electrician	$ 75.00/hr	$ 825.00
	Material (2 cond. 18ga shielded wire)		$ 230.00
	Travel Fees & Truck Charge		$ 149.50
		Sub Total:	**$2,467.50**
		HST 13%	$ 320.78
		TOTAL	**$2,788.28**

Sandcastle Energy Systems Alliance Corporation
2170 Dunwin Drive, Unit 7
Mississauga, Ontario L5L 5M8
Tel: (905) 607-2489
Fax: (905) 607-0419
e-mail: service@sandcastle.ca
www.sandcastle.ca

Marley
Engineered Products

202SLB
Radiant Desk Heater



E152700

Installation, Operation & Maintenance Instructions

IMPORTANT INSTRUCTIONS

GENERAL

This radiant heater is designed to provide supplemental heat in small areas such as offices and may be used as an under desk heater. However, care must be taken to avoid blocking heater or covering it with any thing that could allow it to build up heat – See warnings.

WARNING

When using electrical appliances, basic precautions should always be followed to reduce the risk of fire, electric shock, and injury to persons, including the following:

1. Read all instructions before using this heater.
2. This heater is hot when in use. To avoid burns, do not let bare skin touch hot surfaces.
3. Keep combustible materials such as furniture, pillows, bedding, papers, clothes, and curtains at least 3 feet away from front of heater and keep them away from the sides and rear.
4. Extreme caution is necessary when any heater is used by or near children or invalids and whenever the heater is left operating and unattended.
5. Always turn heater off at switch and unplug heater from outlet when not in use.
6. Do not operate any heater with a damaged cord or plug or after the heater malfunctions, has been dropped or damaged in any manner. Discard heater, or return to authorized service facility for examination and/or repair.
7. Do not use this heater outdoors.
8. This heater is not intended for use in bathrooms, laundry areas and similar indoor locations. Never locate heater where it may fall into a bathtub or other water container.
9. Do not run cord under carpeting. Do not cover cord with throw rugs, runners, or similar coverings. Do not route cord under furniture or appliances. Arrange cord away from traffic area and where it will not be tripped over.
10. Some models are provided with a three blade grounded plug (see Figure 1). If provided with a grounded plug, always connect to a properly grounded outlet only.
11. A heater has hot and arcing or sparking parts inside. Do not use it in areas where gasoline, paint, or flammable liquids are used or stored.
12. Check heater cord and plug connections. Faulty wall outlet connections or loose plugs can cause the outlet or plug to overheat. Be sure the plug fits tight in the outlet. Heaters draw more current than small appliances, therefore overheating of the outlet may occur even if it has not occurred with the use of other appliances. If plug outlet or faceplate is HOT, discontinue use and have qualified electrician check/replace the faulty outlet.
13. Always plug heater directly into a wall outlet/receptacle. Never use with an extension cord or relocatable power tap (outlet/power strip).
14. If this heater is to be used in damp areas such as basements or garages, a ground fault circuit must be provided.
15. Do not make holes in the heater. Damage to internal electrical components or electric shock hazards may occur and this will void your warranty.
16. Use this heater only as described in this manual. Any other use not recommended by the manufacturer may cause fire, electric shock, or injury to persons.
17. This heater is provided with a tip over switch that will disconnect power to the heater if it is tilted or falls over. The heater can only be used in the vertical position or tilted back slightly when used with built in stand.

SAVE THESE INSTRUCTIONS

INSTALLATION INSTRUCTIONS

This heater operates in upright position only. For mounting heater to desk, apply velcro to top of heater back, one piece near each corner. Remove backing from back of velcro and press firmly against the desired position on the desk. Normal position is against the desk knee-well panel with the top of the heater at knee height. To remove, pull bottom of heater firmly away from desk. Heater can be restored to original position by once again attaching to velcro. The leg on the back swings out to support the heater when used as a portable heater.

OPERATING INSTRUCTIONS

1. Heaters are provided with flexible cord with a grounded 2 blade plug (as shown in Figure 1) and built-in ON/OFF switch. This heater is for use at 120 V AC only.
2. An adapter as shown at C in Figure 1 is available for connecting three-blade grounding-type plugs to two-slot receptacles. The green grounding plug extending from the adapter must be connected to a permanent ground such as a properly grounded outlet box. The adapter should not be used if a three-slot grounded receptacle is available.
3. Occasionally a new heater will emit a slight “new smell” odor during initial use. This smell should dissipate within the first hour of use.
4. Always unplug heater when not in use. When heaters are not to be used for an extended period of time, cord should be coiled and tied to prevent damage and heater should be stored in a safe location.

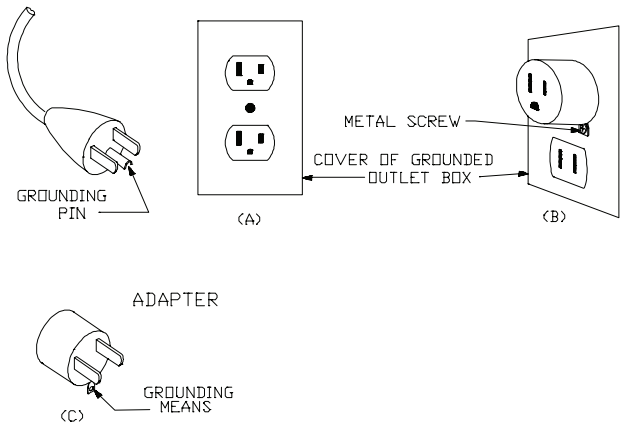


Figure 1

MAINTENANCE INSTRUCTIONS

1. If heater fails to operate or if heater or power cord becomes damaged, unplug and discontinue use. DO NOT attempt to repair the heater. There are no user-serviceable parts inside.
2. If the heater fails during the warranty period, return to place of purchase or to the factory as outlined in the LIMITED WARRANTY statement below.
3. Heater may be cleaned using a damp cloth or sponge and a mild detergent. Never submerge or soak heater in water. Always turn heater off and unplug before cleaning. Heaters may be repainted if desired. Use only high temperature water based acrylic paints.

LIMITED WARRANTY

All products manufactured by Marley Engineered Products are warranted against defects in workmanship and materials for one year from date of installation, except heating elements which are warranted against defects in workmanship and materials for five years from date of installation. This warranty does not apply to damage from accident, misuse, or alteration; nor where the connected voltage is more than 5% above the nameplate voltage; nor to equipment improperly installed or wired or maintained in violation of the product’s installation instructions. All claims for warranty work must be accompanied by proof of the date of installation.

The customer shall be responsible for all costs incurred in the removal or reinstallation of products, including labor costs, and shipping costs incurred to return products to Marley Engineered Products Service Center. Within the limitations of this warranty, inoperative units should be returned to the nearest Marley authorized service center or the Marley Engineered Products Service Center, and we will repair or replace, at our option, at no charge to you with return freight paid by Marley. It is agreed that such repair or replacement is the exclusive remedy available from Marley Engineered Products.

THE ABOVE WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, AND ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WHICH EXCEED THE AFORESAID EXPRESSED WARRANTIES ARE HEREBY DISCLAIMED AND EXCLUDED FROM THIS AGREEMENT. MARLEY ENGINEERED PRODUCTS SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES ARISING WITH RESPECT TO THE PRODUCT, WHETHER BASED UPON NEGLIGENCE, TORT, STRICT LIABILITY, OR CONTRACT.

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above exclusion or limitation may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

For the address of your nearest authorized service center, contact Marley Engineered Products in Bennettsville, SC, at 1-800-642-4328. Merchandise returned to the factory must be accompanied by a return authorization and service identification tag, both available from Marley Engineered Products. When requesting return authorization, include all catalog numbers shown on the products.

HOW TO OBTAIN WARRANTY SERVICE AND WARRANTY PARTS PLUS GENERAL INFORMATION

1. Warranty Service or Parts **1-800-642-4328**
2. Purchase Replacement Parts **1-800-654-3545**
3. General Product Information **www.marleymep.com**

Note: When obtaining service always have the following:
1. Model number of the product
2. Date of manufacture
3. Part number or description

Marley Engineered Products

470 Beauty Spot Rd. East
Bennettsville, SC 29512 USA

Part No. 5200-2184-005

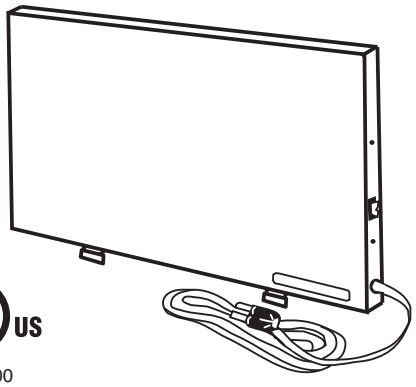
ECR 38730

01/11

Marley
Engineered Products

202SLB

Calefactor radiante de escritorio



E152700

Instrucciones de instalación, operación y mantenimiento

INSTRUCCIONES IMPORTANTES

GENERALIDADES

Este calefactor radiante está diseñado para proporcionar calor complementario en áreas pequeñas tales como oficinas y puede utilizarse como calefactor debajo del escritorio. Sin embargo, debe tenerse cuidado de evitar obstruir el calefactor o cubrirlo con cualquier cosa que pudiera permitirle que acumule calor – Vea las advertencias.

ADVERTENCIA

Al utilizar aparatos eléctricos, siempre se deben seguir precauciones básicas para disminuir el riesgo de incendio, descarga eléctrica y lesiones físicas, incluido lo siguiente:

1. Lea todas las instrucciones antes de utilizar este calefactor.
2. Este calefactor estará caliente mientras está en uso. Para evitar quemaduras, no permita que la piel desnuda haga contacto con las superficies calientes.
3. Mantenga los materiales combustibles, tales como muebles, almohadas, ropa de cama, papeles, ropa y cortinas a al menos 3 pies (0,9 metros) de distancia de la parte delantera del calefactor, y manténgalos alejados de los lados y la parte trasera.
4. Se necesita extrema precaución cuando el calefactor se utiliza cerca de niños o personas discapacitadas y cuando el calefactor se deja funcionando sin supervisión.
5. Siempre apague el calefactor mediante el interruptor y desenchufe el calefactor fuera del tomacorriente cuando no está en uso.
6. No ponga en funcionamiento ningún calefactor con cables o enchufes dañados ni después que el calefactor haya tenido un mal funcionamiento, se haya caído o dañado de cualquier manera. Deseche el calefactor, o regrese al establecimiento de servicio autorizado para inspección y/o reparación.
7. No utilice este calefactor en exteriores.
8. Este calefactor no está diseñado para usarse en baños, áreas de lavado ni en lugares interiores similares. Nunca ubique el calefactor donde pudiera caerse a una bañera u otro recipiente con agua.
9. No tienda el cable debajo de alfombras. No cubra el cable de suministro de energía con alfombras grandes, alfombras continuas ni cubiertas similares. No coloque el cable de suministro de energía debajo de muebles o aparatos. Coloque el cable alejado de las áreas de tráfico y donde éste no cause tropezones.
10. Algunos modelos tienen un enchufe de conexión a tierra de tres patas (vea la Figura 1). Si tiene un enchufe de conexión a tierra, sólo conecte en un tomacorriente conectado a tierra apropiadamente.
11. Un calefactor tiene en su interior piezas calientes, piezas que forman arcos eléctricos o piezas que producen chispa. No utilice esta unidad en áreas donde se utiliza o almacena gasolina, pintura, o líquidos inflamables.
12. Revise las conexiones del cable de suministro de energía y el enchufe del calefactor. Las conexiones defectuosas del tomacorriente de pared o los enchufes flojos pueden causar que el tomacorriente o enchufe se sobrecalienten. Verifique que el enchufe encaja de manera apretada en el tomacorriente. Los calefactores consumen más corriente que los electrodomésticos pequeños, por lo tanto podría ocurrir sobrecalentamiento del tomacorriente incluso si este sobrecalentamiento no había ocurrido con el uso de otros electrodomésticos. Si el tomacorriente o la placa frontal están CALIENTES, interrumpa su uso y solicite a un electricista calificado que revise/reemplace el tomacorriente defectuoso.
13. Siempre enchufe el calefactor directamente en un tomacorriente de pared. Nunca utilice con un cable de extensión o toma de energía reubicable (regleta de tomacorrientes).
14. Si este calefactor debe utilizarse en áreas húmedas tales como sótanos o garajes, debe suministrarse un circuito de protección contra falla a tierra.
15. No haga orificios en el calefactor. Podría ocurrir daño en los componentes eléctricos internos o peligros por descarga eléctrica, y esto anulará su garantía.
16. Utilice este calefactor únicamente según se describe en este manual. Cualquier otro uso no recomendado por el fabricante podría causar un incendio, descarga eléctrica, o lesiones a personas.
17. Este calefactor se suministra con un interruptor por volcamiento que desconectará la energía hacia el calefactor si éste se inclina o cae. El calefactor sólo puede utilizarse en la posición vertical o levemente inclinado hacia atrás cuando se utiliza con la base incorporada.

GUARDE ESTAS INSTRUCCIONES

INSTRUCCIONES DE INSTALACIÓN

Este calefactor funciona únicamente en la posición vertical. Para montar el calefactor en un escritorio, aplique el velcro a la parte superior de la parte trasera del calefactor, un (1) trozo cerca de cada esquina. Retire el forro de la parte trasera del velcro y presiónelo firmemente en la posición deseada en el escritorio. La posición normal es contra el panel de la cavidad para rodillas del escritorio con la parte superior del calefactor a la altura de las rodillas. Para remover, hale firmemente la parte inferior del calefactor alejándola del escritorio. El calefactor puede devolverse otra vez a la posición original adhiriendo al velcro. La pata en la parte trasera gira hacia afuera para soportar el calefactor cuando se utiliza como calefactor portátil.

INSTRUCCIONES DE OPERACIÓN

1. Los calefactores están equipados con cable flexible con enchufe de conexión a tierra de 2 patas (según se muestra en la Figura 1) e interruptor de ENCENDIDO/APAGADO incorporado. Este calefactor sólo es para uso a 120 V AC.
2. Hay disponible un adaptador, según se muestra en C en la Figura 1, para conectar enchufes del tipo de conexión a tierra de tres patas en tomacorrientes de dos ranuras. El terminal verde de conexión a tierra que sobresale del adaptador se debe conectar a una conexión de tierra permanente, tal como una caja de tomacorriente conectado a tierra apropiadamente. No es necesario utilizar el adaptador si hay un tomacorriente de tres ranuras conectado a tierra.
3. Ocasionalmente, un calefactor nuevo despedirá un leve olor “a nuevo” durante el uso inicial. Este olor se disipará dentro de la primera hora de uso.
4. Siempre desenchufe el calefactor cuando no está en uso. Cuando los calefactores no deben utilizarse durante un periodo de tiempo extendido, el cable de suministro de energía debe enrollarse y amarrarse para evitar daño y el calefactor debe guardarse en un lugar seguro.

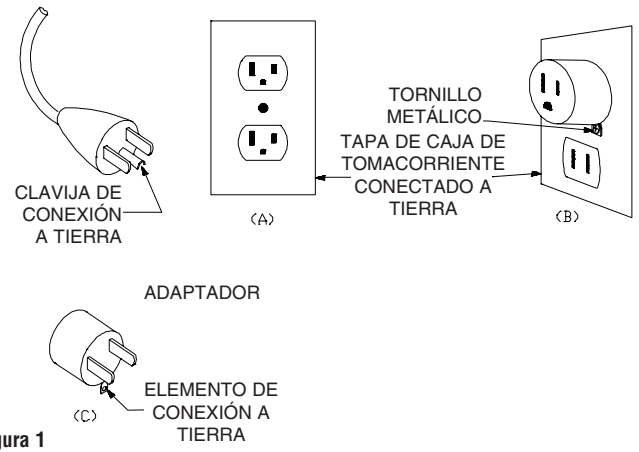


Figura 1

INSTRUCCIONES DE MANTENIMIENTO

1. Si el calefactor no funciona o si el calefactor o el cable de suministro de energía se dañan, desenchufe e interrumpa el uso. El usuario NO debe intentar reparar el calefactor. En su interior no hay piezas reparables por el usuario.
2. Si el calefactor falla durante el período de garantía, devuelva al sitio de compra o a la fábrica según se describe en el siguiente texto de GARANTÍA LIMITADA.
3. El calefactor puede limpiarse utilizando una esponja o trapo húmedo y un detergente suave. Nunca sumerja ni moje el calefactor en agua. Antes de limpiar, siempre apague y desenchufe el calefactor. Si se desea, los calefactores pueden repintarse. Sólo utilice pinturas acrílicas a base de agua para altas temperaturas.

GARANTÍA LIMITADA

Todos los productos fabricados por Marley Engineered Products están garantizados contra defectos en manufactura y materiales durante un (1) año a partir de la fecha instalación, excepto los elementos calefactores los cuales están garantizados contra defectos en manufactura y materiales durante cinco años a partir de la fecha de instalación. Esta garantía no aplica a daño por accidente, uso incorrecto, o alteración; ni donde el voltaje conectado sea superior en 5% al voltaje indicado en la placa de datos; ni se aplica a equipo instalado o cableado o mantenido de manera inapropiada en violación de las instrucciones de instalación del producto. Todas las reclamaciones de trabajo de garantía deben incluir un documento que compruebe la fecha de instalación.

El cliente será responsable de todos los costos incurridos en la remoción o reinstalación de productos, incluyendo los costos de mano de obra, y los costos de envío incurridos para devolver los productos al Centro de Servicio de Marley Engineered Products. Dentro de las limitantes de esta garantía, las unidades inoperantes deben devolverse al centro de servicio autorizado Marley más cercano o al Centro de Servicio de Marley Engineered Products, y nosotros repararemos o reemplazaremos, según nuestra elección, sin costo para usted, con el costo de envío de regreso pagado por Marley. Se acuerda que dicha reparación o reemplazo es el remedio exclusivo disponible de parte de Marley Engineered Products.

LAS ANTERIORES GARANTÍAS REEMPLAZAN CUALQUIER OTRA GARANTÍA EXPRESA O IMPLÍCITA, Y TODAS LAS GARANTÍAS IMPLÍCITAS DE MERCADEABILIDAD Y ADECUADIBILIDAD PARA UN PROPÓSITO EN PARTICULAR QUE EXCEDEN LAS GARANTÍAS EXPRESAS MENCIONADAS SON DENEGADAS MEDIANTE ESTE DOCUMENTO Y EXCLUIDAS DE ESTE ACUERDO. MARLEY ENGINEERED PRODUCTS NO SERÁ RESPONSABLE POR DAÑOS CONSECUENCIALES QUE SURJAN CON RESPECTO AL PRODUCTO, ESTÉN O NO BASADOS EN NEGLIGENCIA, INFRACCIÓN, RESPONSABILIDAD ESTRICTA, O CONTRATO.

Algunos estados no permiten la exclusión o la limitación de los daños resultantes o adicionales, de modo que la anterior exclusión o limitación podría no aplicarse a usted. Esta garantía le otorga derechos legales específicos, y además, usted podría tener otros derechos que varían de un estado a otro.

Para obtener la dirección de su centro de servicio autorizado más cercano, comuníquese con Marley Engineered Products en Bennettsville, SC, en el teléfono: 1-800-642-4328. La mercancía devuelta a la fábrica debe incluir una autorización de devolución y la etiqueta de identificación de servicio, las cuales pueden conseguirse en Marley Engineered Products. Al solicitar la autorización de devolución, incluya todos los números de catálogo mostrados en los productos.

CÓMO OBTENER EL SERVICIO DE GARANTÍA Y LAS PIEZAS DE GARANTÍA, Y ADEMÁS, INFORMACIÓN GENERAL

1. Servicio o Piezas de Garantía **1-800-642-4328**
2. Compra de Piezas de Repuesto **1-800-654-3545**
3. Información General de Productos **www.marleymep.com**

Nota: Al solicitar servicio, siempre tenga a mano lo siguiente:
1. Número de modelo del producto
2. Fecha de fabricación
3. Número o descripción de la pieza

Marley Engineered Products

470 Beauty Spot Rd. East
Bennettsville, SC 29512 USA

Pieza No. 5200-2184-005

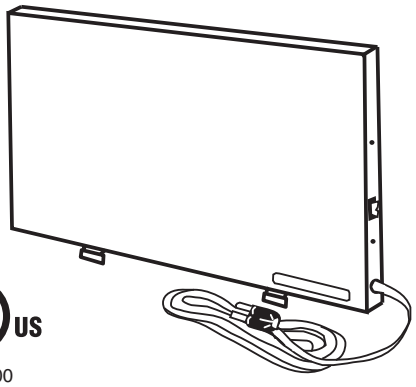
ECR 38730

01/11

Marley
Engineered Products

202SLB

Radiateur rayonnant de bureau



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Instructions d'installation, d'utilisation et d'entretien

INSTRUCTIONS IMPORTANTES

GÉNÉRALITÉS

Ce radiateur rayonnant est conçu pour fournir de la chaleur supplémentaire dans des zones réduites comme des bureaux, et peut s'utiliser comme un chauffage sous le bureau. Cependant il faut veiller à ne pas obstruer le radiateur ou à le couvrir avec tout ce qui pourrait causer sa surchauffe – Consultez les avertissements.

⚠ AVERTISSEMENT ⚠

Lors de l'utilisation d'appareils électriques, des précautions de base doivent toujours être suivies afin de réduire le risque de départ d'incendie, de commotion électrique et de blessures aux personnes, incluant celles qui suivent :

1. Lisez toutes les instructions avant d'installer ou d'utiliser ce radiateur.
2. Ce radiateur est chaud quand il est en fonctionnement. Pour éviter des brûlures, ne laissez pas la peau nue toucher ses surfaces chaudes.
3. Maintenez les matières combustibles comme le mobilier, les oreillers, la literie, les papiers, les vêtements et les couvertures, à au moins 3 pieds (90 cm) de distance de l'avant du radiateur, et éloignez-les aussi des côtés et de l'arrière.
4. Il faut faire très attention quand un radiateur quelconque est utilisé par des enfants ou des personnes invalides ou près d'eux, et à chaque fois que le radiateur est laissé en marche sans surveillance.
5. Coupez toujours le radiateur à son interrupteur et débranchez-le de la prise secteur quand il n'est pas utilisé.
6. Ne faites fonctionner aucun radiateur avec son cordon ou sa fiche secteur en mauvais état, ou après avoir présenté des dysfonctionnements, être tombé ou avec subi de quelconques dommages. Mettez le radiateur au rebut, ou retournez-le à un centre de service agréé pour un examen et/ou une réparation.
7. N'utilisez pas ce type de radiateur à l'extérieur.
8. Le radiateur n'est pas prévu pour une utilisation dans des salles d'eau, des buanderies ou des pièces d'intérieur similairement humides. Ne placez jamais le radiateur à un emplacement d'où il pourrait tomber dans une baignoire ou un autre conteneur avec de l'eau.
9. Ne faites pas passer le cordon d'alimentation sous un tapis. Ne recouvrez pas le cordon avec des carpettes, des passages ou d'autres camouflages. Ne faites pas passer le cordon sous des meubles ou des appareils. Disposez le cordon hors de la zone de trafic et à un endroit où il ne fera pas trébucher.
10. Certains modèles sont fournis avec une fiche d'alimentation à trois lames pour liaison de terre (Voir la Figure 1). Si la fiche d'alimentation fournie a une borne de terre, connectez-la uniquement dans une prise secteur reliée à la terre.
11. Un radiateur comporte à l'intérieur des parties chaudes, et pouvant produire un arc ou des étincelles électriques. Ne l'utilisez pas dans des zones où de l'essence ou des liquides inflammables sont utilisés ou entreposés.
12. Vérifiez le cordon d'alimentation et les connexions de sa fiche. De mauvaises connexions sur une prise secteur murale ou une fiche lâche peuvent causer un sur-échauffement de la prise ou de la fiche. Assurez-vous que le fiche est tenue fermement dans la prise. Les radiateurs tirent plus de courant que des petits appareils, donc une surchauffe de la prise peut arriver même si cela ne s'était pas produit avec d'autres appareils. Si les contacts ou la plaque de face de la prise sont CHAUDS, arrêtez l'utilisation et faites vérifier/remplacer la prise dangereuses par un électricien qualifié.
13. Branchez toujours les radiateurs directement dans une prise secteur murale. Ne les utilisez jamais avec un cordon de rallonge ou un boîtier/une barrette de prises relocalisable.
14. Si le radiateur doit être utilisé dans des endroits humides, comme dans des sous-sol ou garages, il faut prévoir un disjoncteur différentiel en amont.
15. Ne percez pas de trous dans le radiateur. Il pourrait s'ensuivre des dommages aux composants électriques à l'intérieur, avec un risque de commotions électriques, et cela annulerait la garantie.
16. N'utilisez ce radiateur que comme c'est décrit dans ce manuel. Toute autre utilisation non recommandée par le constructeur peut causer un départ d'incendie, une commotion électrique ou des blessures corporelles.
17. Ce radiateur est muni d'un interrupteur sur basculement qui coupera l'alimentation électrique s'il bascule ou tombe. Le radiateur ne peut être utilisé qu'en position droite ou légèrement incliné quand il est sur son socle intégré.

CONSERVEZ CES INSTRUCTIONS

INSTRUCTIONS D'INSTALLATION

Ce radiateur ne fonctionne qu'en position droite. Pour monter le radiateur sur un bureau, appliquez du velcro sur son dos, un morceau près de chaque angle. Enlevez l'isolant du velcro et pressez-le fermement pour le coller contre le bureau à la position désirée. La position normale est contre la plaque cache-genoux, avec le haut du radiateur à la hauteur des genoux. Pour l'enlever, tirez fermement le bas du radiateur en l'écartant du bureau. Le radiateur peut être remis à sa position d'origine en le fixant de nouveau par velcro. La patte à l'arrière se bascule pour supporter le radiateur quand il est utilisé comme modèle portable.

INSTRUCTIONS D'UTILISATION

1. Les radiateurs sont fournis avec un cordon flexible terminé par une fiche d'alimentation à 2 lames (comme montré en Figure 1) et un interrupteur M/A intégré. Ce chauffage n'est prévu que pour du secteur 120 V CA.
2. Un adaptateur, comme montré en C sur la Figure 1, est disponible pour brancher la fiche avec terre à trois lames dans des prises à deux fentes. La fiche de mise à la terre sortant de l'adaptateur doit être reliée à une terre permanente comme celle d'une prise secteur correctement mise à la terre. L'adaptateur ne doit pas être utilisé si une prise secteur à trois fentes est disponible.
3. Parfois un radiateur neuf va générer une nouvelle odeur à sa première utilisation. Cette odeur devrait se dissiper dans la première heure de fonctionnement.
4. Débranchez toujours le radiateur quand il n'est pas en utilisation. Quand les radiateurs restent inutilisés pour une longue durée, leur cordon doit être enroulé et attaché pour éviter des dommages, et les radiateurs sont à entreposer en lieu sûr.

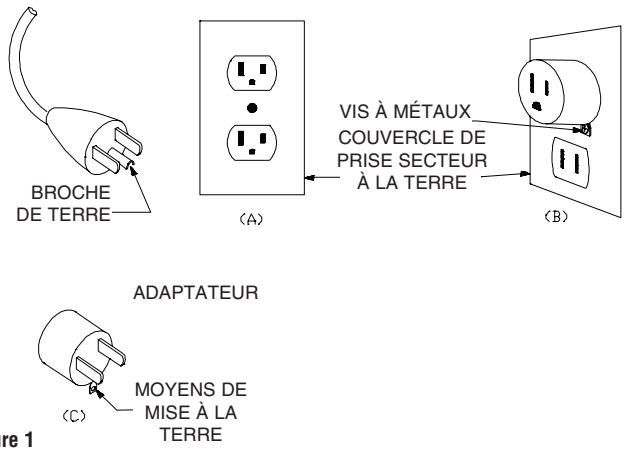

Figure 1

INSTRUCTIONS D'ENTRETIEN

1. Si le radiateur ne fonctionne plus, ou si son cordon devient endommagé, débranchez-le et cessez de l'utiliser. N'essayez PAS de réparer le radiateur. Il ne comporte pas de pièce remplaçable à l'intérieur.
2. Si le radiateur tombe en panne durant la période de garantie, renvoyez-le à l'endroit de son achat ou à l'usine comme décrit dans le descriptif de GARANTIE LIMITÉE qui suit.
3. Le radiateur peut se nettoyer en utilisant un chiffon ou une éponge humide et du détergent doux. Ne submergez pas et ne faites pas tremper un radiateur dans l'eau. Coupez toujours un radiateur et débranchez-le avant de le nettoyer. Les radiateurs peuvent se repeindre si vous le souhaitez. Pour cela n'utilisez que des peintures acryliques à base aqueuse.

GARANTIE LIMITÉE

Tous les produits fabriqués par Marley Engineered Products sont garantis contre des défauts dus à la main d'œuvre et aux matériaux pendant un an à partir de la date d'installation, saufs les éléments de chauffe qui sont garantis de la même façon pendant cinq ans. Cette garantie ne s'applique pas pour des dommages résultant d'accident, de mésusage ou d'altération ; ni si la tension secteur envoyée fait 5 % ou plus au-dessus de la tension nominale de la plaque signalétique ; ni sur l'équipement est incorrectement installé ou câble, en violation avec les instructions d'installation. Toutes les demandes d'exercice de la garantie devront être accompagnées de la preuve de date d'installation.

Le client doit être responsable de tous les coûts occasionnés pour le démontage ou la réinstallation des produits, incluant les coûts de main-d'œuvre, et les coûts d'expédition pour renvoyer les produits au centre de service de Marley Engineered Products. Dans le cadre des limitations de cette garantie, les unités ne fonctionnant pas doivent être renvoyées au centre de service agréé Marley le plus proche, ou directe au centre de service de Marley Engineered Products, où ils seront réparés ou remplacés, à notre choix, sans frais pour vous avec le port de retour payé par Marley. Il est convenu que cette réparation ou ce remplacement sera le seul remède à attendre de Marley Engineered Products.

LES GARANTIES QUI PRÉCÈDENT TIENNENT LIEU DE TOUTES LES AUTRES GARANTIES, EXPLICITES OU IMPLICITES, ET TOUTES LES GARANTIES IMPLICITES DE VALEUR MARCHANDE ET D'ADÉQUATION POUR UNE FINALITÉ SPÉCIFIQUE QUI EXCÉDERAIENT LES DISPOSITIONS DE GARANTIE PRÉCÉDEMMENT ÉNONCÉES SONT ICI REJETÉES ET EXCLUES DE CET ACCORD. MARLEY ENGINEERED PRODUCTS NE SERA PAS TENU POUR RESPONSABLE DES DOMMAGES CONSÉCUTIFS SURVENANT EN RELATION AVEC LE PRODUIT, QU'ILS SOIENT À BASE DE NÉGLIGENCE, TORT, RESPONSABILITÉ PURE OU CONTRACTUELLE.

Certains États ne permettent pas l'exclusion ou la limitation des dommages consécutifs ou annexes, de ce fait l'exclusion ou la limitation qui précède peut ne pas s'appliquer à votre cas. Cette garantie vous donne des droits légaux spécifiques, qui varient d'un État à un autre.

Pour obtenir l'adresse de votre centre de service agréé le plus proche, contactez Marley Engineered Products à Bennettsville, SC, USA, au 1-800-642-4328. Toute marchandise retournée à l'usine doit être accompagnée d'une autorisation de renvoi et d'une étiquette d'identification pour le service, ces deux documents étant disponibles auprès de Marley Engineered Products. En demandant une autorisation de retour, fournissez tous les numéros de catalogue indiqués sur les produits.

COMMENT OBTENIR DU SERVICE ET DES PIÈCES DANS LE CADRE DE LA GARANTIE ET DES INFORMATIONS GÉNÉRALES

1. Service et pièces sous garantie **1-800-642-4328**
2. Pièces détachées à acheter **1-800-654-3545**
3. Informations générales sur les produits **www.marleymep.com**

Remarque : Pour obtenir le service sous garantie vous devez toujours avoir préparé :
1. Référence de modèle du produit
2. Date de fabrication
3. Numéro ou description de pièce

Marley Engineered Products

470 Beauty Spot Rd. East
Bennettsville, SC 29512 USA

N° de document 5200-2184-005

ECR 38730

01/11

GRAHAM
ENGINEERING ANSWERS

QUOTATION

DATE	May 19, 2014	Rev 0
GRAHAM REFERENCE EG	2248TOR14	
TYPE OF EQUIPMENT	Heliflow Heat Exchanger	
CUSTOMER	Blue Sky Energy Engineering	
CUSTOMER'S INQUIRY	Received May 15, 2014	

FOR FURTHER INFORMATION REGARDING THIS QUOTATION
PLEASE CONTACT

GRAHAM REPRESENTATIVE:
T. D. Rooke Associates Ltd
Email: mverbari@tdrooke.com

PREPARED BY
Matt Starowitz
Mstarowitz@graham-mfg.com

THE FOLLOWING ARE ENCLOSED AND ARE A PART OF THIS QUOTATION

- General Commercial Comments
- Technical Comments
- Specification Sheets
- Terms and Conditions
- Preliminary Drawings

GRAHAM
ENGINEERING ANSWERS

QUOTATION

Customer:	Blue Sky Energy Engineering		Date:	May 19, 2014
EG Number:	2248TOR14	Rev. 0	Engr:	MLS

EQUIPMENT PRICING

Item No.	Qty.	Graham Designation / Description	Est Wgt (Ea) lbs	Unit Price (USD)	Line Total (USD)
01	1	Model 12XF-16S Graham Heliflow Heat Exchanger with copper tubes, cast bronze manifolds, cast iron shell side, and ASME Section VIII, Div 1 construction and stamp with CRN. Tube MAWP: 200 PSIG @ 350 F Shell MAWP: 65 PSIG @ 350 F Construction: ASME with CRN	170	$7,231	$7,231
		TOTAL US Funds FCA Batavia, NY			**$7,231.**

*****Quoted shipment based on timely receipt of CRN approval by provincial authority. Should a delay in CRN approval occur, we will advise the shipment impact at that time.

VALIDITY

This quotation is valid for 14 days.

SCHEDULE

Equipment ready for shipment (FCA Batavia NY)	8-10	Weeks after receipt of a purchase order

* Delivery schedule based on no drawing approval.

TERMS OF PAYMENT

Graham offers a 1.5% discount for immediate payment with order via credit card. Please include credit card information at time order is placed for the discount to apply.

Terms of payment are 100% net 30 days after shipment, subject to credit approval.

Final purchase order acceptance, including commercial and payment terms, is subject to review by our Sales and Credit Departments. The Buyer will be notified in writing of any changes in the commercial and/or payment terms for a mutually agreed upon contract between both parties.

TERMS AND CONDITIONS OF PURCHASE

This quotation is based on the General Conditions of Sale, Form GMC 1002-E.

GENERAL COMMERCIAL COMMENTS

Purchase orders should be made out to Graham Corporation, 20 Florence Avenue, Batavia, NY 14020. Your order will be processed and invoiced from our facility in Batavia, New York. Please send your

order to the Order Entry Department by email to orderentry@graham-mfg.com or by fax to 585-815-2008. Please reference the Graham EG number above.

Quoted prices are net to Graham in USA funds and do not include any brokerage, export or import fees, duties or licenses, General Sales Tax, Value Added Tax, or other taxes beyond those normally applicable to Graham as an equipment manufacturer in Batavia, NY, USA. Customs clearance and all expenses are to the customer's account.

Release for Purchase - Release to purchase critical materials is required at time of receipt of an order. Equipment delivery is subject to availability of materials at time of order entry.

Should termination / cancellation become necessary, cancellation charges shall include costs of materials received, cancellation charges incurred for materials on order, costs for work completed or in progress, and normal overhead burden, administration charges and a reasonable profit on that portion of the work completed.

Files provided to Graham may be modified electronically for internal use. This is not done to violate the owner's rights but merely to allow efficient processing of project requirements.

Graham's liability on any claim of any kind, including negligence, for any loss or damage arising out of, connected with, or resulting from this transaction, or the design, manufacture, sale, delivery, resale, installation, technical direction of installation, inspection, repair, operation, or use of any equipment covered by or furnished hereunder, shall in no case exceed the price paid by Buyer for the equipment. Graham also disclaims all liability, whether in contract, tort, warranty, or otherwise, to any party other than Buyer. Graham shall not be liable for any special, indirect, incidental or consequential damages.

GRAHAM
ENGINEERING ANSWERS

HELIFLOW HEAT EXCHANGER SPECIFICATION SHEET

Customer:	Blue Sky Energy Engineering	Graham Ref.No.:	EG-2248TOR14
Customer Ref:		Date:	May 19, 2014
Item:		Engineer:	MLS

Performance

		Inside Coil	Outside Coil
Description of fluid circulated		WATER	WATER
Specific Gravity		0.995	0.985
Specific Heat	BTU/lb F	1.000	0.997
Thermal Conductivity	BTU/hr ft F	0.359	0.370
Viscosity (Film For Liquids)	cP	0.764	0.595
Rate of Flow	gpm	5.00	3.00
Rate of Flow	lb/hr	2487.45	1477.08
Temperature Entering Heliflow	F	55.00	176.00
Temperature Leaving Heliflow	F	110.00	83.12
Calculated Pressure Drop	psi	1.29	0.24
Operating Pressure	psig	20.00	1.00
Design Pressure	psig	200.00	65.00
Hydrostatic Test Pressure	psig	CODE	CODE
Design Temperature	F	350.00	350.00
Connection Sizes	in	2"	2"
Connection Type		MNPT	FNPT
Total Duty	BTU/hr	136828.59	
Total Surface Supplied	ft2	17.40	
Model		12XF-16S	
Coil Spacing		STD	
Tubes 3/8 Dia 18 BWG	COPPER	Manifolds	CAST BRONZE
BasePlate	CAST IRON	Bolts	Steel
Casing	CAST IRON	Gaskets	Non-Asbestos
Tubes To Manifold Joint:	Brazed		
Code of Construction:	ASME SECT.VIII, DIV.1 W/ STAMP		

General

Price F.O.B Batavia, N.Y.:	
Shipment:	
Weight	170.00 lb

Remarks

Terms Conditions of Sale per GMC-1002-E unless otherwise indicated.

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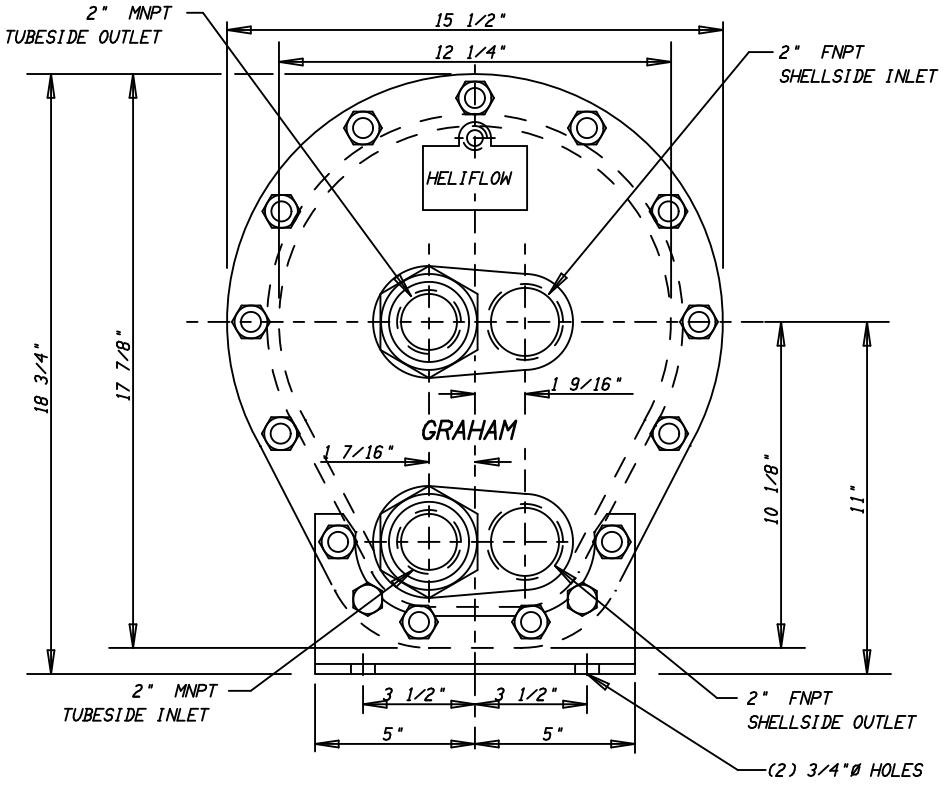
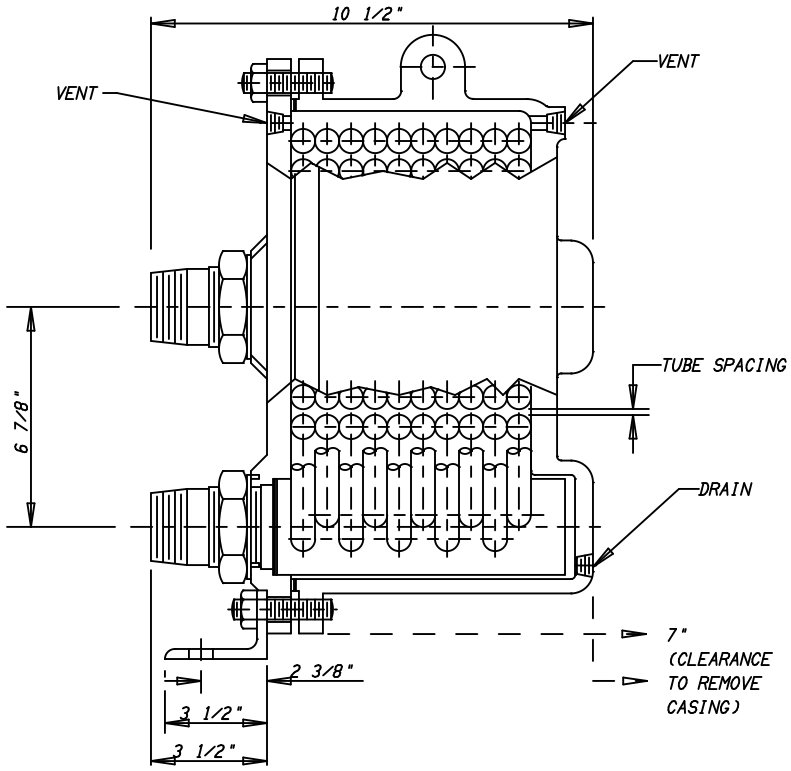
Graham Corporation, 20 Florence Avenue, Batavia, New York 14020
Tel.: 585-343-2216 Fax: 585-343-1097 E-MAIL equipment @ graham-mfg.com WEBSITE:http://www.graham-mfg.com





CUSTOMER:	Blue Sky Energy Engineering
CUSTOMER REF. NO.--	
GRAHAM REF. NO.--	2248TOR14
DESIGN/CONSTRUCTION	ASME SECT.VIII, DIV.1 W/ STAMP
STAMPING:	ASME
ITEM NO:	

NOTES:
1. OVER PRESSURE PROTECTION MUST BE PROVIDED PRIOR TO PLACING VESSEL IN SERVICE.
2. PULSATING PUMPS MUST HAVE ADEQUATE PULSATION DAMPENERS PROVIDED.
3. ALL VENT & DRAINS ARE 1/4" NPT (PLUG).
4. INLETS AND OUTLETS CAN BE REVERSED. OUTLET MUST BE NEXT TO INLET.

HELIFLOW MATERIAL LIST		
PART NAME	MATERIAL	SPEC. NO.
BASE PLATE	CAST IRON	SA-278-40
CASING	CAST IRON	SA-278-40
TUBES	COPPER	SB-75-122
MANIFOLDS	CAST BRONZE	SB-584-922
GASKETS	NON-ASBESTOS	NON-ASBESTOS
BOLTING	ALLOY STEEL	SA-193-B7,SA-194-2H
SUPPORT	CARBON STEEL	SA-36

	M.A.W.P. (P.S.I.G.)	TEMPERATURE MDMT/DESIGN (DEG F)	HYDRO TEST (P.S.I.G.)	WEIGHT
SHELL SIDE	65	- / 350	CODE	170 LB
TUBE SIDE	200	- / 350	CODE	

PRELIMINARY

GRAHAM CORPORATION

GRAHAM CORPORATION
20 FLORENCE AVE. BATAVIA, NEW YORK

12XF-16S HELIFLOW

SCALE	MADE	CHKD	DATE	DWG. NO.	REV.
NONE	MLS	MLS	MAY 19, 14	S1093(2248TOR14)	0

GENERAL CONDITIONS OF SALE

1. This offer to sell is expressly conditioned on Buyer's acceptance of all terms and conditions hereof, which shall take precedence over any inconsistent, contradictory or additional terms and conditions contained in any request for quotation, purchase order or other document furnished by Buyer in connection with this transaction whether such documents are exchanged simultaneously with this offer or prior or subsequent thereto, and Buyer's acceptance and receipt of the goods shipped hereunder shall constitute acceptance of such terms and conditions contained herein. No acceptance by Seller shall be deemed contained herein except upon Buyer's express written consent to all terms and conditions set forth herein additional to or different from those of Buyer.

All price and delivery quotations shall expire thirty (30) days from date thereof and in the meantime may be changed or withdrawn at any time.

The beneficiary named on any purchase order or similar form furnished by Buyer should be "Graham Corporation" c/o the name and address of the local sales office through which Buyer's order is placed.

2. SHIPPING DATE - FORCE MAJEURE: Shipment dates are from the date of receipt of Buyer's order with complete manufacturing information or from the date of approval of drawings, when required. It is understood that Buyer will accept this equipment, at an earlier date if Seller is able to ship it sooner than such specified shipment date. Seller may ship any portion of the equipment contingent upon good freight cost practices, as soon as it is completed and payment therefor shall be in accordance with agreed terms of payment. If shipment is delayed at buyer's request or by reason of other causes beyond Seller's control, payment shall become due under the terms of payment from the date equipment is reported ready for shipment, and Buyer further agrees to pay appropriate storage charges in the event Seller is compelled to store the equipment. Storage of such goods will be at Buyer's risk.

Seller shall not be liable for any loss or damage for delay or non-delivery due to governmental acts or regulations or any civil or military authority, acts of Buyer or by reason of any force majeure, which shall be deemed to mean all other causes whatsoever not reasonably within the control of Seller, including but not limited to acts of God, war, riot or insurrection, blockades, embargoes, sabotage, epidemics, storms, floods, earthquakes, labor disputes, lockouts or other industrial disturbances, delays of carriers, interruption of power, and inability to secure materials. Any delay resulting from any such cause shall extend shipping dates correspondingly. Seller shall in no event be liable for any special, indirect or consequential damages arising from delay or non-delivery irrespective of the reason therefor, and receipt by Buyer shall constitute acceptance of goods and waiver of any claims due to delay.

3. CANCELLATION OR TERMINATION: If Buyer shall cancel or terminate this order, such cancellation or termination shall only be upon written notice to Seller, and in such event, Buyer shall pay to Seller Seller's reasonable charges, including but not limited to, a quantity price adjustment for any goods delivered, and all other costs incurred and committed for by Seller, and Seller's pro rated profit thereon.

4. SUSPENSION: If Seller's performance of the work is delayed for a period of more than six (6) months by reason of any cause set forth in paragraph two (2), above, upon removal of the cause of any such delay, performance shall be resumed, delivery rescheduled, and the purchase price shall be subject to any price increase in effect at the time of resumption of performance. If Buyer is unwilling to accept such adjusted purchase price and such rescheduled delivery date, it shall cancel its order as provided in paragraph three (3) above.

5. TERMS OF PAYMENT: Unless otherwise specified, the equipment offered herein is quoted FOB Seller's plant. The terms of payment are quoted in U.S. Funds, payable net 30 days after date material is shipped or is reported ready for shipment. These terms are applicable to partial as well as complete shipments. A 1½% SERVICE CHARGE per month will be applicable to outstanding balances past 30 days.

If applicable, progress payments will be stated in the proposal.

When in the opinion of Seller the financial conditions of Buyer renders it appropriate, Seller may require cash payment or satisfactory security before each shipment.

6. WARRANTY AND LIABILITY LIMITATION: THE FOLLOWING IS IN LIEU OF ALL WARRANTIES OF SELLER EXPRESSED OR IMPLIED AND ALL IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND/OR ANY OTHER OBLIGATION ON THE PART OF THE SELLER ARE HEREBY EXCLUDED: Seller, except as otherwise provided, warrants goods of its own manufacture against faulty workmanship or the use of defective materials, under normal use and service, and that such goods will conform to mutually agreed upon written specifications, drawings, and is guaranteed to meet specified performance requirements, for a period of twelve (12) months from date of shipment of the goods from the factory.

Seller assumes no responsibility for deterioration of the equipment due to corrosion, erosion, or flow induced tube vibration, or for fouling, maintenance problems or any other causes not specifically covered under the foregoing warrant. The sole remedy of Buyer with respect to any part not conforming to any warranty of Seller shall be the Repair or, at Seller's option, replacement of any defective part at the point of manufacture, Buyer assuming all costs of removal, shipping and reinstallation, provided that immediate written notice of the defect has been given to Seller, and Seller shall not be liable for any other expenses incurred because of failure of any part to meet Seller's warranty, nor for any special, indirect or consequential damages. Material returned to Seller's factory without its written consent will not be accepted. No back charges will be honored without Seller's advance approval of the work to be performed. Seller's liability on any claim of any kind, including negligence, for any loss or damage arising out of, connected with, or resulting from this transaction, or the design, manufacture, sale, delivery, resale, installation, technical direction of installation, inspection, repair, operation, or use of any equipment covered by or furnished hereunder shall in no case exceed the price paid by Buyer for the equipment. Seller also disclaims all liability, whether in contract, tort, warranty, or otherwise, to any party other than the Buyer.

7. DRAWINGS AND DESIGN CHANGES: Proposal drawings submitted with Seller's offer are intended only to show the general style, arrangement and approximate dimensions of the equipment and are not certified for field installation. Only when specifically requested by Buyer will Seller submit plans or certified drawings for Buyer's approval. Shop detail drawings shall not be furnished under any circumstances since they are proprietary.

Should Buyer request changes Seller shall have the option of adjusting contractual delivery dates and increasing original purchase price for design and material changes required to comply with Buyer's changes, however, Seller shall notify Buyer of such additional charge and schedule change prior to proceeding with the modification. Should Buyer approve plans and/or drawings without change, Seller shall then proceed with fabrication of the equipment in accordance with such approval. Should Buyer subsequently request changes after fabrication has commenced, Seller shall notify Buyer of schedule and cost impacts and upon approval, Buyer shall be responsible for Seller's additional charges.

8. **TITLE-RISK OF LOSS-FREIGHT-ROUTING:** Unless otherwise agreed in writing, the equipment purchased hereunder shall be delivered F.O.B. Seller's place of manufacture. Title, possession and risk of loss from any damage or casualty to the equipment, regardless of cause, shall be upon Seller until Seller has delivered the equipment to the carrier. Buyer agrees that Seller shall retain and Buyer hereby grants to Seller a security interest in the equipment only until the purchase price has been paid and Buyer agrees to perform all acts necessary to perfect and assure Seller's security interest

In the event of any loss or damage or shortage in transit on a sale where it is expressly agreed in writing that Seller is responsible for the freight, and/or that the F.O.B. is other than Seller's place of manufacture, Buyer must make notation on the carrier's delivery receipt of said loss or damage or shortage, and make this document available to Seller and as further provided in paragraph 9.

Buyer shall pay to Seller, in addition to the purchase price, any amount by which transportation charges may be increased, by reason of increased transportation rates, between dates of proposal and the actual shipping date.

Seller may ship or route as Seller deems reasonable in the circumstances and is authorized to ship the goods by carrier. Should premium transportation be required such as air or exclusive use of truck, Buyer agrees to reimburse Seller the difference between normal and premium transportation costs on all orders sold with freight included.

9. SHORTAGES: No claims for shortages, errors or breakage will be recognized by Seller unless made in writing within 30 days after receipt of goods at destination, accompanied by transportation bill with notation thereon.

10. INSURANCE: No insurance coverage shall be provided by Seller unless by special agreement expressly consented to by Seller.

11. TAXES: Any tax imposed by any present or future law on the sale of equipment described herein shall be added to the purchase price stated herein and is the responsibility of Buyer. Seller is registered to collect sales tax in the States of California, Connecticut, Florida, Indiana, Michigan, Missouri, New Jersey, New York, North Carolina, Texas, and Washington and Buyer shall provide, if applicable, acceptable certification that it is exempt from such taxes, and in all other jurisdictions Buyer shall reimburse the proper tax authorities.

12 WAIVER OR MODIFICATION: The terms and conditions stated herein constitute the entire agreement between the parties relating to this transaction and no addition to or modification of any provision hereof shall be binding upon Seller unless made in writing and signed by a duly authorized representative of Seller. No waiver by Seller of any provision set forth herein shall constitute a waiver of any other provision.

13. APPLICABLE LAW: The validity, performance and construction of any agreement between Buyer and Seller shall be governed by the laws of the State of New York.

14. ESCALATOR CLAUSE: Form GMC-1002-E Rev No. 3 Supplement 4/80 dated _____ is attached hereto and is made part of the General Conditions of Sale. Escalator is/is not applicable.

15. CREDIT CARDS: The payment will be processed on the purchased date. Note that all shipping and handling costs will be charged at that time.

Form GMC-1002-E

PRODUCTS

Our leadership position in vacuum systems and heat transfer equipment is based on decades of proven experience, and backed by thousands of units designed to maximize efficiency and to operate with trouble-free performance.

VACUUM SYSTEM PRODUCTS

Ejectors
- Steam Jet Ejectors
- Organic Motivated Ejectors
- Thermocompressors
- Steam Vacuum Refrigeration

Eductors
- Sulfur Pit Eductors
- Liquid Eductors

Liquid Ring Vacuum Pumps
- Vacuum
- Compressors
- Packaged Vacuum Systems
- Hybrid Systems

Process Vacuum Condensers
- Shell & Tube
- Direct Contact
- Overhead Pre-Condensers
- Freeze Condensers

Steam Surface Condensers
- Turbine-Generator Condensers
- Mechanical Drive Condensers

Direct Contact Condensers
- Horizontal Barometric Condenser
- Vertical Barometric Condenser
- Low Level Barometric Condenser

After Market Support
- Spare Parts
- Field Support and Troubleshooting
- Technical Support

HEAT TRANSFER PRODUCTS

Heliflow Heat Exchangers
- Cryogenic Vaporizers and Coolers
- Vent Condensers
- Vaporizers
- Gas Coolers
- Liquid to Liquid
- Sample Coolers
- Seal Coolers

Plate Heat Exchangers
- Brazed
- Gasketed

Micro-Mix II Instantaneous Hot Water Heaters
- Steam Heating
- Hot Water Heating

Desuperheaters
- Steam
- Gas

After Market Support
- Spare Parts
- Field Support and Troubleshooting
- Technical Support

VacAdemics Educational Seminar is where your vacuum equipment knowledge and understanding is taken to the next level. The two-day training seminar combines classroom with hands-on operation of vacuum equipment. Certain equipment is built in glass construction so you are able to visualize what is presented in the classroom. See how a vacuum system actually responds to process changes or variation of utilities. Class schedule is available on Graham website.

PALSER ENTERPRISES LTD.

*1885 Blue Heron Drive * London, Ont. N6H 5L9*
*PH: (519) 471-9382 * FAX: (519) 471-1049 * E-MAIL: sales@palserent.com*

QUOTATION

NORTEC HUMIDIFICATION SYSTEMS

PROJECT: **MUSEUM LONDON** **QUOTATION #:**

LOCATION: **LONDON** **DATE:4/11/14**

ENGINEER: **CITY OF LONDON** **CLOSING:**

REFERENCE	PRODUCT	DESCRIPTION	NET PRICE
HEADER			
AHU-1	96" HEADER INSULATION, 3" CC		363.00
AHU-2	90" HEADER INSULATION, 3" CC		339.00
STEAM TUBES			
AHU-1	29 "A" 48" STEAM TUBES INSULATION FOR ABOVE		
AHU-2	27 "A" 48" STEAM TUBES INSULATION FOR ABOVE		13,950.00

F.O.B.: OTTAWA, FREIGHT ALLOWED
TERMS: NET 30 DAYS
TAXES: EXTRA
QUOTATION VALID FOR: 45 DAYS

STU LIDDELL

CUSTOMER QUOTATION

Quote # :	3393
Project Name:	MARK EDWARDS
Quote Date:	
Sales Rep:	

Billing Information:

MARK EDWARDS

BLUE SKY ENERGY

LONDON ONTARIO

905 855 9209

Phone: 1+888-232-4956
Fax: 1+905-660-6581

The Choice of the informed

Shipping Information:

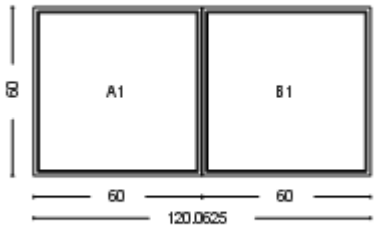
MARK EDWARDS

BLUE SKY ENERGY

LONDON ONTARIO

905 855 9209

Line	Width [in]	Height [in]	Location	Options	Qty	Total
1-1	Frame Size: 120.063 x 60		None Assigned	Exterior Color? : White Interior Color? : White Strap Anchors?: 22 A1: 4 mm(1 9/16")TRI.2XSC.SS.ARG.CL.Ann. B1: 4 mm(1 9/16")TRI.2XSC.SS.ARG.CL.Ann. A1: 300 Series DirectSet Rectangle - 60 x 60 - Fix B1: 300 Series DirectSet Rectangle - 60 x 60 - Fix RO Size: 120.813 x 60.75	5	$6,755.80



Triple glazed

2 x soft coat LowE

argon gas

super spacer

Order Notes:

Thank you for the opportunity to quote your project.
Please note: This quote is valid for 30 Days.
All windows are viewed from outside.
Products included in this quote are Fibertec standard product line.

	Customer Price
SubTotal :	$6,755.80
H.S.T. :	$878.25
G.S.T. :	$0.00
Freight :	$0.00
Installation :	$0.00
Total :	$7,634.05

PRICE QUOTED FOB FIBERTEC

FREIGHT TO BE DETERMINED ONCE SHIPPING ADDRESS IS KNOWN

QUOTE # 14-1682-SL

RE: London Museum

www.biddle.ca / www.thermoscreens.ca

TO: Blue Sky Engineering
Mississauga, ON

Attn: Mark Edwards
PH#: 416-258-2808

Email: mark@bskyeng.com

Sean Lyn
Regional Manager of Ontario
Biddle Air Systems Ltd. / Thermoscreens Canada
11 King Street, Unit # 3
Barrie, Ontario L4N 6B5
Mobile: 647-222-3359 / Toll Free: 1-866-827-2474
Office: 705-797-0007 / Toll Free: 1-866-693-4333
Fax: 705-797-0013

Date of Quote: 6-May-14

Quote is valid for 60 days from date of quote.

Qty	Description	Unit Price	Total Price
1	**Door Opening 15' x 15'** Biddle Hot Water Heated Free Hanging Air Curtain model IndAC L-450-W3 600/3/60 (consisting of two (2) IndAC L-225-W3 mounted and wired in tandem) complete with a door contact switch and a controller. The unit comes with a five (5) year on-site warranty. The main casing is supplied in Blue (RAL 5023) and the air inlet and discharge grilles in the color titan (Polydrox). Other colors are available at an extra charge.	$23,645.00	$23,645.00

NOTE:
- Unless otherwise noted, approximate lead-time is 6 - 8 weeks, after receipt of order.
- Quote is based on supply of equipment only.
- All taxes extra.
- Freight is FOB Barrie, Ontario.
- Terms: NET 30 O.A.C.
- We accept Visa / MasterCard

GERRIE
Passionately Helping Customers Be More Successful.

HEAD OFFICE
4104 South Service Rd., Burlington, ON L7L 4X5
(905) 681−3656 Fax (905) 681−1774
www.gerrie.com

Servicing Branch
Burlington Branch
4104 South Service Road
Burlington ON L7L 4X5
905 681−3660
Fax: 905 632−1606

QUOTATION

Quote No.	2945972
Print Date	May 22 2014
Bill To:	160787
Ship To:	160787
Page No.	1 of 1

SOLD TO
Blue Sky Electric Ontario Inc
120 Byron Ave
Kitchener ON M2C 1Z8

SHIP TO
Blue Sky Electric Ontario Inc
120 Byron Ave
Kitchener ON M2C 1Z8

make it count

Management System Registered to ISO 9001

CUSTOMER REF. NO.	REQUESTED BY	DATE ENTERED	ENTERED BY
rfq		May 21 2014	BTHOMSON
TERMS:		**FREIGHT TERMS**	
Net One Month		Freight Prepaid & Add	
COMMENTS			

LINE	ITEM DESCRIPTION	CUSTOMER ITEM	EST DEL DATE	QUANTITY ORDERED	UOM	UNIT PRICE	PRICE UOM	DISC. %	EXTENDED AMOUNT
1.000	25B−E027N104 PF 525 600V 3PH 25HP IP20	7−10 Days	05/21/2014	1	EA	4,153.6000	EA	NET	4,153.60
2.000	25B−E019N104 PF 525 600V 3PH 15HP IP20	7−10 Days	05/21/2014	1	EA	2,481.6000	EA	NET	2,481.60
3.000	1321−3R25−B 1321 Power Component 25 A Line	7−10 Days	05/21/2014	1	EA	311.5200	EA	NET	311.52
4.000	1321−3R18−B 1321 Power Component 18 A Line	Stock	05/21/2014	1	EA	268.4000	EA	NET	268.40
5.000	BALIDVSM4103T−5 25HP Frame 284TC Motor	6−7 Weeks	05/21/2014	1	EA	3,182.5700	EA	NET	3,182.57
6.000	BALIDVSM2333T−5 15HP, Frame 254TC Motor	6−7 Weeks	05/21/2014	1	EA	2,311.5500	EA	NET	2,311.55

VALID FOR 30 DAYS (Excluding Wire, Cable and Conduit)
Acceptance of order is subject to approval by Gerrie's Credit Department.
Material returns are subject to inspection by the Branch and if approved for credit may be subject to restocking charges.
Order cancellations for non−stock products may be subject to cancellation charges.
This quotation is our interpretation of the available information at the time of the quotation. It is the responsibility of the customer to confirm this bill of material. We are pleased to submit this quotation based on our standard Terms and Conditions.
If you have any questions, please do not hesitate to contact sender.

Please Contact:

Bruce Thomson
E−mail: bthomson@gerrie.com
Phone: 905 681−3660
Fax: 905 632−1606

Sub Total	**12,709.24**
Shipping and Handling	
HST	**1,652.20**
Total Amount	**CAD$ 14,361.44**

AirTest™
Sensors That Make Buildings Smart!

Weather Station Quality Humidity, Temp & Dew Point Probes
High Accuracy + Long Term Stability + Affordability

Ideal For Accurate Economizer Control

The AirTest Radiation Shield is designed to protect temp & RH sensors from inaccuracy due to sun, wind, rain & snow effects.

Modbus Output

Voltage (0-10 V)

The Problem With Economizer Control

In theory, fresh air economizers can save hundreds or thousands of dollars by providing free cooling when outside conditions are right. In practice, these tremendous savings are most often lost because:

- Poor accuracy sensors result in increased cooling loads.
- Many sensors drift or fail within a year.
- Temperature and enthalpy sensor by their nature let in excess moisture that decreases comfort and increase cooling/dehumidification load.
- Poor performing sensors extend economizer operating hours where there are no savings and where the possible energy benefits of CO_2 demand controlled ventilation are lost.
- The cost of servicing and replacing sensors provide an ongoing burden on maintenance budgets.

The AirTest Economizer Solution

1. Provide a sensor with high accuracy and proven long term stability in outdoor environments that can resist effects of salt air and a variety of pollutants.
2. Use a radiation shield to ensure sensor accuracy is not degraded by sun, wind, rain and snow effects.
3. Provide a way to control an economizer based on temperature and dew point. Dew point is critical in ensuring that excessive moisture is not introduced to the building.
4. Deliver a *"weather-station-quality"* product at a price that ensures a economizer payback in two years or less.

Benefits Of This Approach

✓ Applying dew point and temperature control for economizers ensures that outside air for free cooling never exceeds inside moisture design conditions, thereby saving energy and ensuring comfort.

✓ The AirTest radiation shield minimizes significant reading error that can occur with unprotected or poorly mounted outside air sensors.

✓ In a networked system, one probe and radiation shield can be used to control all air intakes on a building, offering a major cost saving while providing a significant increase in quality over in-unit sensing.

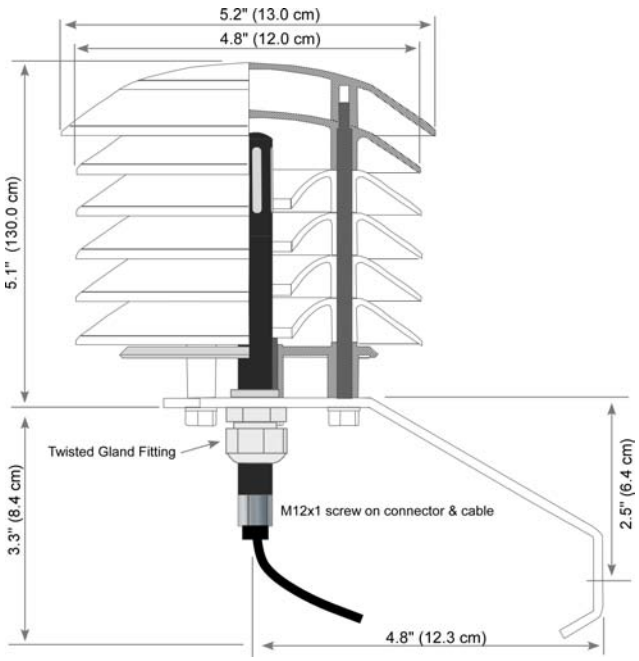
✓ The screw-on probe design allows easy removal of the probe for commissioning or calibration verification.

✓ The probe sensor element is treated with a proprietary environmental coating that protects the sensor from pollutants and salt air that will degrade most outside air sensing elements.

✓ The AirTest probe and radiation shield approach provides weather station accuracy and durability to ensure optimum economizer savings over the life of the HVAC equipment. Long term testing has shown minimal drift in over 7 years of outdoor operation.

Radiation Shields & Outdoor Air

Even the most accurate outside air sensor is worthless if it is subject to interference from solar radiation, wind, rain and snow. The AirTest radiation shield is a economical essential accessory that minimizes these outdoor air challenges and ensures an accurate outdoor air measurement.



The RM1000 Radiation Shield can be used with all temperate & moisture probes available from AirTest including: EE060, EE061, EE07, EE071, EE08, EE23 (Model C).

Coming Soon For Stand-Alone Economizers

AirTest probes will easily communicate with networked building control systems but may not be compatible with stand-alone economizers. AirTest will soon be introducing the EC2021 Economizer Control Interface module that will utilize a probe output and provide analog and relay outputs for dew point and temperature that can interface to an economizer controller. Two adjustable pot screws can be positioned to the desired temperature and dew point set points. The status of the module is provided by four indicator lights. The module is din rail mountable or easily mounted in a standard electrical enclosure.

Further Reading Reference From AirTest

AirTest Dew Point Economizer Guide
Proper Moisture Measurement… Its The Dew Point Stupid
Dew Point Control Solutions
AirTest Dew Point Control Products

Outdoor Air Probe Options

EE060

0-10V Out
Temperature
RH

Filter Cap

- Protects sensor against dust and dirt.

Sensor Element

- Built to Automotive Quality Standards AEC-Q200
- Designed for long term stability (7-10 years)
- Environmental coating protects against salt air, pollutants and liquid spray/condensation
- "Weather Station" quality sensor designed for outside air measurements

Probe Enclosure

- Electronics sealed within UV resistant probe
- Durable, rugged packaging
- Calibration information retained in probe electronics

Screw-On Probe Fitting

- Easy to install/replace
- Provides water-tight seal.
- Cable provides M12x1screw-on fitting and open wire leads.

EE071

Modbus (RS485) Out
Temperature
RH
Dew Point
Mixing Ratio

Probe Model No:	EE060*	EE071
Output Signal:	0-10 V	modbus
Temp:	Y	Y
Moisture:	RH	RH, Dew Point, Mixing Ratio, Abs Humidity
RH Accuracy:	±2.5%	±2%
Temp Accuracy:	±0.5ºF (±0.3ºC)	±0.36 (±0.02ºC)
DP Accuracy:	±1.4 ºF Td	± 1.1 ºF Td
Power In:	15-30VDC	4-18VDC
Probe Diameter:	0.5" (12mm)	0.5" (12 mm)
Probe Length:	5.4" (170 mm)	3" (75 mm)
Probe Color:	Black	White
Connector	M12x1 Screw On	M12x1 Screw On
Protective Environmental Coating	Yes	Yes
Datasheet Link	Click Here	Click Here
Kit with Probe, Radiation Shield & 6' (2 m) Cable	EC1001	EC1002

** For use with systems that can calculate dew point from RH & T.*

AirTest™ Technologies Inc. specializes in the application of cost effective, state-of-the-art air monitoring technology to ensure the comfort, security, health and energy efficiency of buildings.

AirTest™
Sensors That Make Buildings Smart!

APPENDIX D:

List of Major Equipment

Detailed Description of Major Equipment:

Description	Make / Model / Details
A01 – Unit over 15yrs old. System balanced 2004.	(Supply Fan Design= 20,277 CFM); 25hp, GEC Machines, XR236624-20
A02 – Unit over 15yrs old. System balanced 2004.	(Supply Fan Design= 17,200 CFM); 25hp, Wattsaver, 150118-22
A03 – Unit over 15yrs old. System balanced 2004.	(Supply Fan Design= 11,000 CFM); 10hp, Lincoln T-3014
A04 – Unit over 15yrs old. System balanced 2004.	(Supply Fan Design= 11,000 CFM); 15hp, GEC Machines XR226440-14
A05 – Unit over 15yrs old. System balanced 2004.	(Supply Fan Design= 11,000 CFM); 15hp, GEC Machines XR226440-14
A06– Unit over 15yrs old. System balanced 2004.	(Supply Fan Design = 4,356 CFM, Engineered Air, Model LM-6-C); 7.5hp, Baldor EM3311T-5
Return Fan #1,	(Tested Capacity=35,865CFM) 20hp Leeson N256T17FB7B
Return Fan #2,	(Design = 10,000 CFM) 330 Ultrafoil Fan, 5hp ADL Induction Motor DO-499064
Return Fan #3,	(Design = 25,653 CFM)Optima TEFC, 15hp General Electric 142084
Chiller #1,	130 Ton (Used in summer) Trane; Serial# U09A02942; 2009
Chiller #2,	130 Ton (Used in summer) Trane; Serial# U09A02942; 2009
Chiller #3,	60 Ton (Used in winter) Trane;
Chilled Water Pumps,	2 x 10HP Armstrong Pumps
Hot Water Pumps,	2 x 2HP Bell & Gossett Pumps
DHW Tank	Steam Turbomax; Thermo 2000
DHW Reheat and Storage, 30kW	AO Smith; DVE-120;