Hunter's Point South

Intermediate School & High School

Long Island City, NY

M E C H A N I C A L O P T I O N

Technical Report Three

Mechanical Systems Existing Conditions Evaluation

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Table of Contents

Figures and Tables

Executive Summary

The purpose of thesis technical report three is to provide a summary of the mechanical system for Hunter's Point South Intermediate School & High School. This includes investigating the design requirements, external influences, mechanical equipment, and operating controls. Hunter's Point South School is a new schoolhouse for grades 5 through 12 which is located in Long Island City, New York. It was commissioned by the NYC School Construction Authority and designed to the guidelines of the NYC Green School Guide. Construction of the schoolhouse began recently on January 10th, 2011 and is expected to be complete on October 7th, 2013.

Hunter's Point South School uses six air handler units to heat, cool, and ventilate spaces. The first three air handlers make up a variable air volume system that serves the classrooms, offices, corridors, and non-public areas. The other three air handlers are constant air volume which serve the gymnasium, kitchen/cafeteria, and auditorium. A propylene glycol – water mixture is used for heating and cooling in the building. The boilers and chillers are located on the roof along with all the air handling units to save usable floor space. There is plenty of room around mechanical equipment for maintenance but there is only stair access to these systems. This would make replacing large parts difficult, potentially impossible.

The mechanical system first cost is $7,750,000 ($50.50 per square foot). The custom air handlers and extensive ductwork make up a third of this cost. The operating cost for the mechanical system is $294,212 a year. Compared to the base building, Hunter's Point South School will save 28.3% in yearly energy cost. However, no heat is recovered from any processes in the building so further energy savings are still possible.

Hunter's Point South Intermediate School & High School's mechanical system met all the design requirements, even the high standards set by the New York City Green School Guide. Overall the system looked very good but there is still room for improvement. The analysis outlined below will come in great help in finding potential areas for redevelopment that can be used in my thesis proposal.

Building Overview

Hunter's Point South Intermediate School & High School is a public school for grades 5 through 12 serving the PS 287 Queens School district. Hunters Point is a five story school that will house over 1,000 students. It consists of 26 classrooms, 8 special education classrooms, library, gym, assembly space, cafeteria with open terrace seating, kitchen, and support spaces. The building is a part of the Hunter's Point South Project, a redevelopment of the 30 acre Queens area to become a more sustainable, middle income urban community along the waterfront park. This redevelopment in Queens also includes residential housing, apartments, retail space, community/cultural facilities, parking, and a new 11 acre waterfront park.

Mechanical System Overview

Conditioned air is served to Hunter's Point South Intermediate School & High School via the six rooftop air handling units. Units 1, 2, and 3 are variable air volume (VAV) systems that service the classrooms, offices, corridors, and non-public spaces. Units 4, 5, and 6 are constant air volume (CAV) systems that serve the gymnasium, cafeteria/kitchen, and auditorium, respectively. All air handling units have variable frequency drives, wrap around heat pipes for dehumidification, and economizer controls. Preheat coils in the AHU's use a 35% propylene glycol – water mixture while the cooling coil utilizes a 30% propylene glycol – water mixture. This heat-transfer fluid has low toxicity and volatility. It poses little harm to humans in case of a leak.

Four natural gas fired, condensing boilers are used for Hunter's Point South School's heating needs. These boilers are located in the mechanical penthouse's boiler room. Each boiler can produce 1860 MBH worth of 35% propylene glycol – water mixture which is used for the AHU's, perimeter fin tube radiators, unit heaters, and cabinet heaters. All heating hot water and secondary pumps are located in the boiler room along with the hot and chilled water expansion tanks. Two 276 ton air cooled chillers with scroll compressors are also located on the roof. A 30% propylene glycol – water mixture is cooled by the R-410a refrigerant which is used for the AHU's cooling coils.

Cabinet and unit heaters are used to heat the building's entrances, locker rooms/showers, and stairwells. Split heat pumps are utilized in the telecom rooms on each floor, food storage, and elevator machine room. The outdoor section of each heat pump is located on the roof. Fin tubed radiators are used along the perimeter walls to heat the space in conjunction with AHU's. Upblast and mushroom fans are located on the roof where they exhaust air from the science lab's fume hoods and kitchen.

Design Objectives, Requirements, and Conditions

Hunter's Point South School is a schoolhouse for grades 5 through 12 which is located in Queens, New York. It is part of the Hunter's Point South Project which is a process to redevelop the 30 acre area in Queens to become a more sustainable, middle income urban community. Hunter's Point South School's architecture as well as building maintenance was designed with this idea in mind. The school is also held to the requirements of the New York City Green School Guide which further reinforces the strive for a green, efficient building.

The classrooms house a large number of occupants which consumes a huge amount of energy. Since the classrooms have a fluctuating number of occupants throughout the day, it would be costly and inefficient to run the rooms at full load all day for ventilation and lighting. This was considered in the design so to help reduce energy consumption, VAV boxes were used to vary the flow of conditioned air to the spaces. Occupancy sensors for lighting control were also included to save electricity.

Hazardous chemicals are used in the laboratories and science classrooms. This inherent concern was accounted for in the design phase. Fume hoods with exhaust fans are used to help flush out potentially harmful chemicals while fan powered VAV boxes are used to replenish the exhausted air. Strict standards were imposed on the quality of duct used for the chemical exhaust and the inside of the ducts are negatively pressurized to prevent leakage of the chemical exhaust to surrounding spaces.

Hunter's Point South School was commissioned under the New York City Board of Education. All new schoolhouses in New York City must abide by the New York City Green School Guide. The NYC Green School Guide is a document that outlines standards that new schools must follow. The standards outlined are geared towards making these new schoolhouses more energy efficient and sustainable. Since Hunter's Point South School must follow this, no emphasis was put forth to go for LEED certification (even though the NYC Green School Guide is fairly similar to the USGBC's LEED rating system).

The NYC Board of Education has commissioned many school houses as well as created ties with power companies in the area. This has led to beneficial relations between the board and power companies. An agreement between the New York Power Authority (NYPA) and the NYC Board of Education resulted in reduced rates of electricity for Hunter's Point South School. The NYPA is one of the country's largest state public power organizations which produce some of the cheapest electricity in North America. The energy rates used for Hunter's Point South School can be seen below in Table 1.

Energy Prices	
Type	Price
Electricty (based on NYPA)	\$0.0553/kWh
	\$21.49/kW
Natural Gas (based on National Grid firm charges)	\$1.579/ccf
	\$1.542/therms
	\$11.65/month

Table 1 – Energy Prices

Hunter's Point South School is located in Long Island City, New York in the Queens borough. It sits in the Mixed-Humid Climate Zone according to ASHRAE Standard 90.1 and has roughly 5,400 heating degree days or fewer. Below in Table 2 are the outdoor design conditions for the school.

ASHRAE HoF 2009 Chapter 14 Appendix: Climate Data	
JFK Airport, NY	dB Temp
0.4% Cooling	89.7°F
99.6% Heating	12.8°F

Table 2 – Outdoor Design Air Conditions

Table 3 below shows the room design conditions for the spaces in Hunter's Point South School.

Room Design Temperatures	
Winter	72°F Dry Bulb
Summer	75°F Dry Bulb

Table 3 – Indoor Design Conditions

Design Ventilation

Appendix A contains the excel spreadsheets of each air handler's results for minimum outdoor air intake using the calculations from ASHRAE Standard 62.1-2007 Section 6 for ventilation. For AHU's 4, 5, and 6, the minimum ventilation supplied to each room is contrasted against the design condition. The NYC Green Schools Guide requires all new schools, such as Hunter's Point South Intermediate School & High School, to be designed to use above 30% minimum ventilation air calculated in ASHRAE Standard 62.1. This is outlined in Q1.1R Minimum IAQ Performance/Increased Ventilation in the NYC Green Schools Guide. Compliance with this increase in air has also been added to the analysis and can be seen Table 4 below.

	Type	Min OA Intake	Vot	Compliant?	30% Above Vot	Above 30% Compliant?
AHU-1	VAV	14945	12218	Yes	15883	No
AHU-2	VAV	19445	18971	Yes	24662	No
AHU-3	VAV	13210	10954	Yes	14240	No
AHU-4	CAV	13360	7085	Yes	9211	Yes
AHU-5	CAV	11840	6259	Yes	8488	Yes
AHU-6	CAV	6325	2657	Yes	3454	Yes

Table 4 – Air Handling Units' Section 6 of ASHRAE Standard 62.1 Compliance

Since Hunter's Point South School is located in Queens, New York ventilation requirements must be checked against both the ASHRAE Standard 62.1-2007 Section 6 and the New York State Mechanical Code 2007 using values from Section MC 403. The zone primary outdoor air fraction (Z_p) values found using the NYS Mechanical Code are slightly higher than the ASHRAE ones. However, these values are not shown because they are irrelevant in the end. They are irrelevant because the above 30% outside air calculated from ASHRAE Standard 62.1 dominates the New York State Mechanical Code values. This 30% increase makes the ASHRAE required outside air the driving factor in this comparison.

Mechanical Equipment Summary

The mechanical systems in Hunter's Point South School are primarily located on the roof. Two air cooled chillers and six air handling units are located here along with the outdoor sections of each of the heat pumps and many of the exhaust fans. The mechanical penthouse on the roof houses the four condensing boilers along with their pumps and the expansion tanks. The emergency generator is also located in a room in the penthouse. The roof space is mainly used for the mechanical equipment because no basement exists for Hunter's Point South School. Due to direct exposure to the elements on the roof, a propylene glycol – water mixture has been used instead of water to prevent freezing in the pipes and coils. Below in Tables 5 through 8 is the breakdown of information for the boilers, chillers, heat pumps, and exhaust fans, respectively.

Boiler Schedule							
Unit No.	Location	Type	Heating Capacity (MBH)	Efficiency (minimum)	EWT	LWT	Horsepower
B-1, B-2, B-3, or B-4	Boiler Room (on roof)	Gas Fired Condensing Boiler	1860	85.3%	120°F	140°F	56

Table 5 – Boiler Schedule

Chiller Schedule							
Unit No.	Location	Type	Capacity (tons)	COP/ EER	EWT	LWT	GPM
ACH-1 or ACH-2	Roof	Air cooled with scroll compressors	276	3.25/11.1	54°F	44.4°F	710

Table 6 – Chiller Schedule

Heat Pump Schedule					
Unit No.	Service	Air Flow (CFM)	Heating Capacity (MBH)	Cooling Capacity (MBH)	System EER
AC-1	Telecom Room	790	45	42	15.8
AC-2	Telecom Room	425	0	12	13.8
AC-3	Telecom Room	425	0	12	13.8
AC-4	Telecom Room	425	0	12	13.8
AC-5	Telecom Room	425	18	12	13.8
AC-6	Food Storage	425	18	12	13.8
AC-7	Elevator Machine Room	425	0	12	13.8

Table 7 – Heat Pump Schedule

Exhaust Fan Schedule					
Unit No.	Service	Location	Type	Capacity (cfm)	Motor HP
Ke-1	Kitchen Gneral Exhaust (5th Flr)	Roof	Upblast	3000	1.5
Ke-2	Kitchen Hood Exhaust (5th Flr)	Roof	Upblast	7050	5
Ke-3	Can Wash Room Exhaust (5th Flr)	Roof	Mushroom	320	1/4
EF-1	Fume Hood Exhaust	Roof	Nozzle	1300	1.5
EF-2	Fume Hood Exhaust	Roof	Nozzle	1300	1.5
EF-3	Science Lab General Exhaust	Roof	Mushroom	700	1/3
EF-4	Fume Hood Exhaust	Roof	Nozzle	1300	1.5
EF-5	Main Toilets & Locker Room Exhaust	Roof	Mushroom	5910	3
EF-6	I/S Boy's & Girl's Locker Room Exhaust	Roof	Mushroom	1060	1/2
EF-7	H/S Boy's & Girl's Locker Room Exhaust	Roof	Mushroom	1440	3/4
EF-8	Copy Room Exhaust	Roof	Mushroom	300	1/4
EF-9	Kitchen Men's & Women's Toilet	Roof	Mushroom	400	1/6
EF-10	General Exhaust	Plumbing Room (1st Flr)	In-Line	1310	1/2
EF-11	Electric Service Room Exhaust	Equipment Room (1st Flr)	In-Line	1000	1/3
EF-12	Fuel Oil Tank Room Exhaust	Fuel Oil Room (1st Flr)	In-Line	220	1/4
EF-13	Emergency Generator Room Exhaust	Generator Room	In-Line	650	1/4
EF-14	Elevator Machine Room	Equipment Storage (1st Flr)	In-Line	220	1/4
EF-15	Gas Meter Room	Gas Room (1st Flr)	In-Line	220	1/4
EF-16	Kitchen Detergent Room	Roof	Mushroom	100	1/6
EF-17	Kiln Unit	Roof	Mushroom	150	1/6
EF-18	Acid Storage Cabinets	Roof	Mushroom	150	1/6
SF-1	Boiler Room Supply	Boiler Room	In-Line	850	1/4

Table 8 – Exhaust Fan Schedule

AHU-1, AHU-2, and AHU-3 are all part of a variable air volume system. VAV boxes are used to manage the flow of air to the spaces served by these air handlers in an attempt to save energy costs. Each air handler (AHU-1 through 6) has variable frequency drives, wrap around heat pipes for dehumidification, and the ability to run in economizer mode. Temperature drops across the heating coils and heating terminal units is 20°F. The cooling coils in the air handlers have a 10°F temperature drop across them. Table 9 below shows the AHU's breakdown.

Air Handler Unit Schedule											
Unit No.	Service	Location	Type	Supply/Return CFM	Minimum OA/Exhaust CFM	Heating Capacity (MBH)	Cooling Capacity (MBH)	Supply Fans	Supply Fan HP (each)	Return Fans	Return Fan HP (each)
AHU-1	Classrooms, Offices, Corridors, and Non-Public	Roof	VAV	30,000/27,000	14,945/11,945	1,266.8	1,389.7	2	30	2	15
AHU-2	Classrooms, Offices, Corridors, and Non-Public	Roof	VAV	31,700/27,100	19,445/14,845	1,367.7	1,562.8	2	30	2	15
AHU-3	Classrooms, Offices, Corridors, and Non-Public	Roof	VAV	27,000/24,300	13,210/10,510	1,111.4	1,270.9	2	25	2	10
AHU-4	Gymnasium	Roof	CAV	20,860/18,560	13,360/11,060	1,232.5	1,222.9	2	20	2	7.5
AHU-5	Café/Kitchen	Roof	CAV	18,700/12,500	11,840/5,640	1,096.5	916.2	1	40	1	10
AHU-6	Auditorium	Roof	CAV	9,600/9,200	6,325/5,925	443.8	492.0	1	20	1	10

Table 9 – Air Handler Unit Schedule

Information for the pumps used in Hunter's Point South School can be seen below in Table 10. Note that pumps P-1, P-2, and P-3 distribute a 35% propylene glycol water mixture while P-4 through P-6 distribute a 30% propylene glycol water mixture. FOP-1 and FOP-2 both pump fuel oil for the emergency generator.

Pump Schedule					
Unit No.	Service	Location	Capcaity (GPM)	Head (ft)	Motor Size (HP)
P-1	Heating Hot Water	Boiler Room (on roof)	330	110	20
P-2	Heating Hot Water (Stand-By)	Boiler Room (on roof)	330	110	20
P-3	Heating Hot Water	Boiler Room (on roof)	330	110	20
P-4	Secondardy Chilled Water (ACH-1)	Boiler Room (on roof)	710	100	30
P-5	Secondary Stand By for P-3 or P-5	Boiler Room (on roof)	710	100	30
P-6	Secondardy Chilled Water (ACH-2)	Boiler Room (on roof)	710	100	30
FOP-1 or 2	Emergency Generator on Roof	Plumbing Room (1st Flr)	2	18	1/2

Table 10 – Pump Schedule

Heating and Cooling Loads

Below in Table 11 are the results for the building loads calculated in TRACE. AHU's 1, 2, and 3 serve the classrooms, offices, corridors, and non-public spaces. AHU's 4, 5, and 6 serve the gymnasium, cafeteria/kitchen, and auditorium, respectively. The stairs and main entrances were modeled as well. "Other" refers to the collection of the restrooms, telecom rooms, electrical closets, and mechanical penthouse. The diversity of the loads created by each different space can be seen through the zones. As expected, the heating load is greater than the cooling load. This is no surprise considering the school is located in New York and is mainly occupied during the heating season with little occupancy for summer session.

	Conditioned Space (sf)	Supply Air per unit area (cfm/sf)		Area per Cooling Capacity (sf/ton)	Cooling Capacity per Area (tons/sf)	Heating Capacity per Area (Btuh/sf)	Total Heating (Btuh)	Total Cooling (tons)
		Cooling	Heating					
AHU-1	30637	0.6	0.37	379.6	0.0026	36.53	1,119,300	80.7
AHU-2	29722	0.89	0.5	274.9	0.0036	51.17	1,521,000	108.1
AHU-3	22567	0.82	0.51	271.9	0.0037	48.89	1,103,300	83.0
AHU-4	12735	1.77	1.77	107.6	0.0093	105.79	1,347,200	118.4
AHU-5	11449	1.34	1.34	208.2	0.0048	85.71	981,300	55
AHU-6	4341	1.34	1.34	144.7	0.0069	118.13	512,800	30
Stairs	1584	n/a	1.1	n/a	n/a	71.21	112,800	n/a
North and South Entrances	668	n/a	0.13	n/a	n/a	8.53	5,700	n/a
Other	4711	n/a	0.17	n/a	n/a	10.27	48,400	n/a
Total Building	118414	0.904	0.710	256.1	0.0040	57.02	6,751,800	475.2

Table 11 –TRACE Loads

Below in Table 12 are the loads calculated by the mechanical engineers in Elite Software.

	Conditioned Space (sf)	Supply Air per unit area (cfm/sf)	Area per Cooling Capacity (sf/ton)	Cooling Capacity per Area (tons/sf)	Heating Capacity per Area (Btuh/sf)	Total Heating (Btuh)	Total Cooling (tons)
AHU-1	28115	0.9801	286.5	0.0035	37.82	1,063,259	98.12
AHU-2	27690	1.0412	232.5	0.0043	48.83	1,351,976	119.1
AHU-3	21646	1.1427	234.6	0.0043	43.36	938,642	92.25
AHU-4	12527	1.4766	113.8	0.0088	70.87	887,731	110.1
AHU-5	9833	1.624	144	0.0069	80.1	787,669	68.27
AHU-6	4341	2.0131	110.7	0.009	84.01	364,697	39.21
Stairs	1080	2.9079	186.3	0.0054	65.47	70,713	5.8
South Entrance	800	0.7225	0	0	31.29	25,034	0
Total Building	106032	1.2022	201	0.005	51.77	5,489,721	532.85

Table 1 –Elite Software Loads

Overall the results do not seem too unreasonable. The total heating load calculated in TRACE is 23% percent higher than the mechanical engineers' model while the total cooling load calculated in TRACE is 11% lower. However, when a closer look is taken zone by zone some discrepancies do occur. Table 13 shows a percent comparison for heating and cooling loads between the two models.

Percent Difference in Trace vs. Elite Software Loads		
	Heating	Cooling
AHU-1	-5%	18%
AHU-2	-13%	9%
AHU-3	-18%	10%
AHU-4	-52%	-8%
AHU-5	-25%	19%
AHU-6	-41%	23%
Stairs	-60%	n/a
Entrances	77%	n/a
Total	-23%	11%

*Note: Negatives mean Trace value is higher than Elite Software value.

Table 13 – Percent Differences in Models

An in depth discussion outlining the possible reasons for the differences in the TRACE load calculation and the Elite Software model can be seen in Technical Assignment 2. The main discrepancies can be due to that a lower U-value was used for the exterior façade in the TRACE model. This caused the lower cooling loads to be found using TRACE. The higher heating loads for the model ran in TRACE is largely due to extra rooms being added that only require heating. Spaces that were not served by the air handlers, besides the stairwells and entrances, were not accounted for in the design engineers' Elite Software model. Overall, the load calculations found using TRACE were not too far off from the design engineers' values.

Annual Energy Usage

Below in Table 14 is the speculated annual energy consumption for Hunter's Point South School. Since the schoolhouse is not complete, no actual measured values exist but the table has the projected values for the annual energy consumption as calculated in TRACE as well as the designer's estimates.

	Electricty (kWh per year)	Natural Gas (BTU x 10^6 per year)	Electricity Cost per year	Natural Gas Cost per year	Total Cost per year	Cost per Square Foot of Building
TRACE	1,079,329	6449.1	$ 170,668	$ 85,703	$ 256,371	$ 1.67
Design Engineer	1,030,849	6,441	$ 194,745	$ 99,467	$ 294,212	$ 1.91
Difference	-5%	0%	12%	14%	13%	13%

Table 14 – Energy Consumption TRACE Model

System Operations and Schematics

Air Side

AHU's 1, 2, and 3

Below in Figure 1 is a schematic for a typical VAV AHU (AHU 1, 2, or 3) as well as a terminal VAV box. This AHU serves the classrooms, offices, corridors, and non-public areas with the necessary heating, cooling and ventilation needed. The return fan and supply fan are both equipped with variable frequency drives (VFD) so air can be modulated to the spaces or from them depending upon the needs. The minimum outside damper is opened whenever the AHU is in use. All AHU's have the ability to run in economizer mode so the controls operating the damper motors of the minimum outside air, maximum outside air, and exhaust air dampers are all linked together. As much as 100% outside air can be supplied. A temperature sensor (TS) and humidity sensor (HS) measure the return air conditions. A TS and HS are also located outside the AHU to measure the outdoor conditions. The readings from the return air sensors and outdoor air sensors work in conjunction with the space requirements to run the economizer mode which modulates the dampers. Both the heating coil and cooling coils use two way valves to modulate the amount of the propylene glycol – water mixture flow. The heating coil performs the function of a preheat coil as well as having the ability to serve as a regular heating coil.

The dehumidification of the supply air is accomplished by the wrap-around heat pipes (which wraps around the cooling coil). A precool heat pipe is upstream of the cooling coil while a reheat heat pipe is downstream. The precool heat pipe brings the warm air temperature down bringing it closer to its dew point. Dehumidification can then occur across the cooling coil and the reheat heat pipe then brings the supply air back up to its appropriate temperature. A solenoid control valve is used to modulate the flow through the heat pipes which is controlled by the outdoor and return humidity sensors. Finally a pressure sensor on the return and supply side checks to make sure the pressure is balanced. If the pressure is off, the fans will vary flow to remedy this.

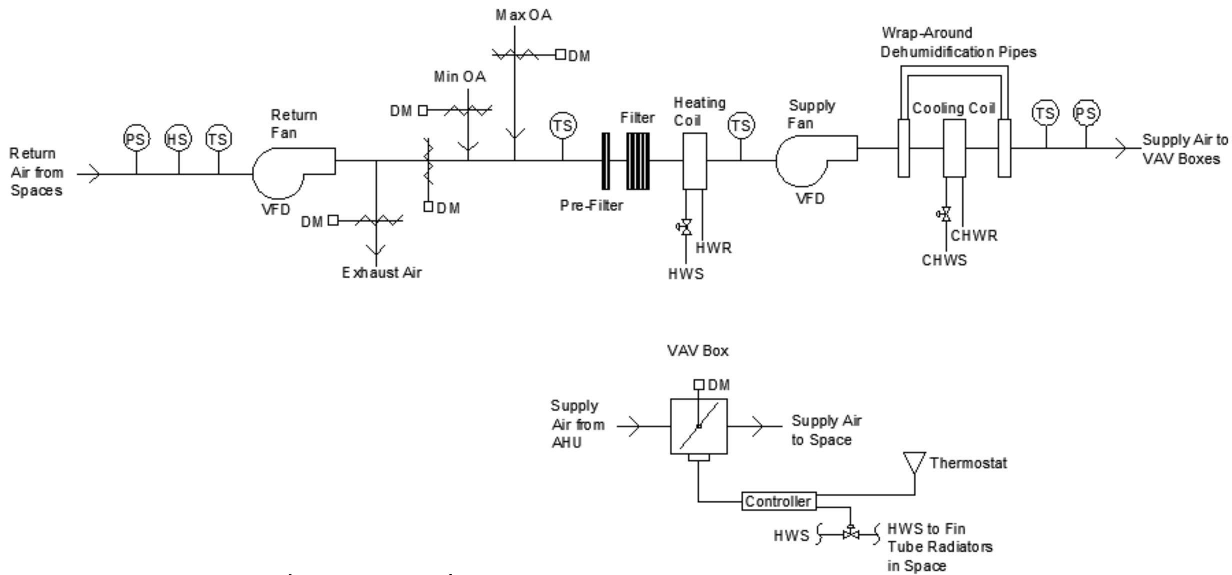

Figure 1 – VAV AHU and VAV Box Schematic

The VAV box modulates based upon the space's need. The controller is run by the thermostat in the room and controls the damper motor and hot water supply to the fin tube radiators. Each VAV box has a minimum turndown so each space will still receive minimum ventilation.

AHU's 4, 5, and 6

AHU's 4, 5, and 6 are constant air volume systems. The AHU's serve the gymnasium, cafeteria/kitchen, and auditorium, respectively. Each fan motor in the AHU's has a VFD and the ability to run in economizer mode. A VFD is provided on the fans to ensure that the proper CFM will be maintained when the filters get dirty. A schematic for AHU 4, 5, or 6 can be seen below in Figure 2. Essentially the AHU's work like the VAV AHU's above except that there are no VAV terminal boxes and a constant volume of air is supplied.

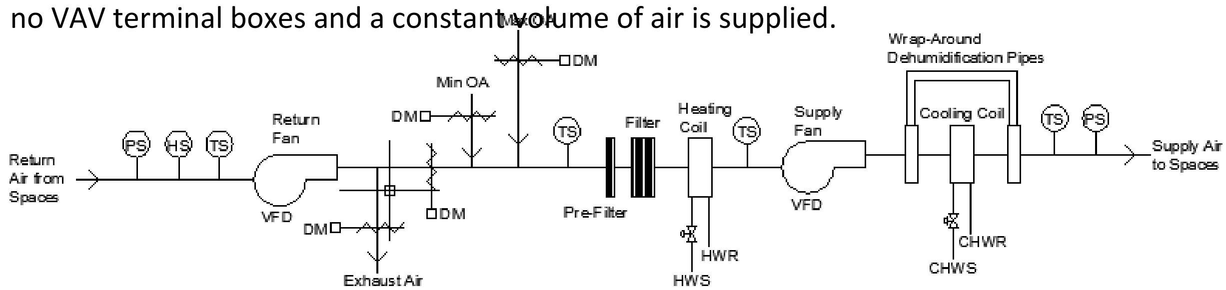

Figure 2 – CAV AHU

Water Side

Chilled Water System

The chilled water system is composed of two packaged air-cooled water chillers in parallel that serve the cooling coils of the AHU's. This system can be seen below in Figure 3. Each chiller contains two VFD pumps in parallel and its own glycol pump and tank. Two pumps are used for redundancy (one being stand by). The chilled water system is a variable primary flow system. The flow through the shell and tube evaporator modules in each chiller varies with the load at the AHU's. The chilled propylene glycol – water mixture is supplied at a temperature of 44.4°F and sent to the AHU's cooling coils. The return temperature is designed to be 54°F, giving an approximate ΔT of 10°F for cooling. The chilled propylene glycol – water mixture supplied from the chillers can bypass the cooling coils through the low flow bypass. This bypass is controlled by a differential pressure sensor across it. When the load at the terminals can no longer be met by one chiller, the second chiller will modulate on. An air separator and expansion tank are located on the return side of the chilled water. Temperature sensors are located on the upstream and downstream of the chillers to determine the loads needed to be produced by the evaporators and that the chillers are operating properly. A flow sensor (GPM in schematic) is used to measure flow from the chillers and to check that the system is functioning properly.

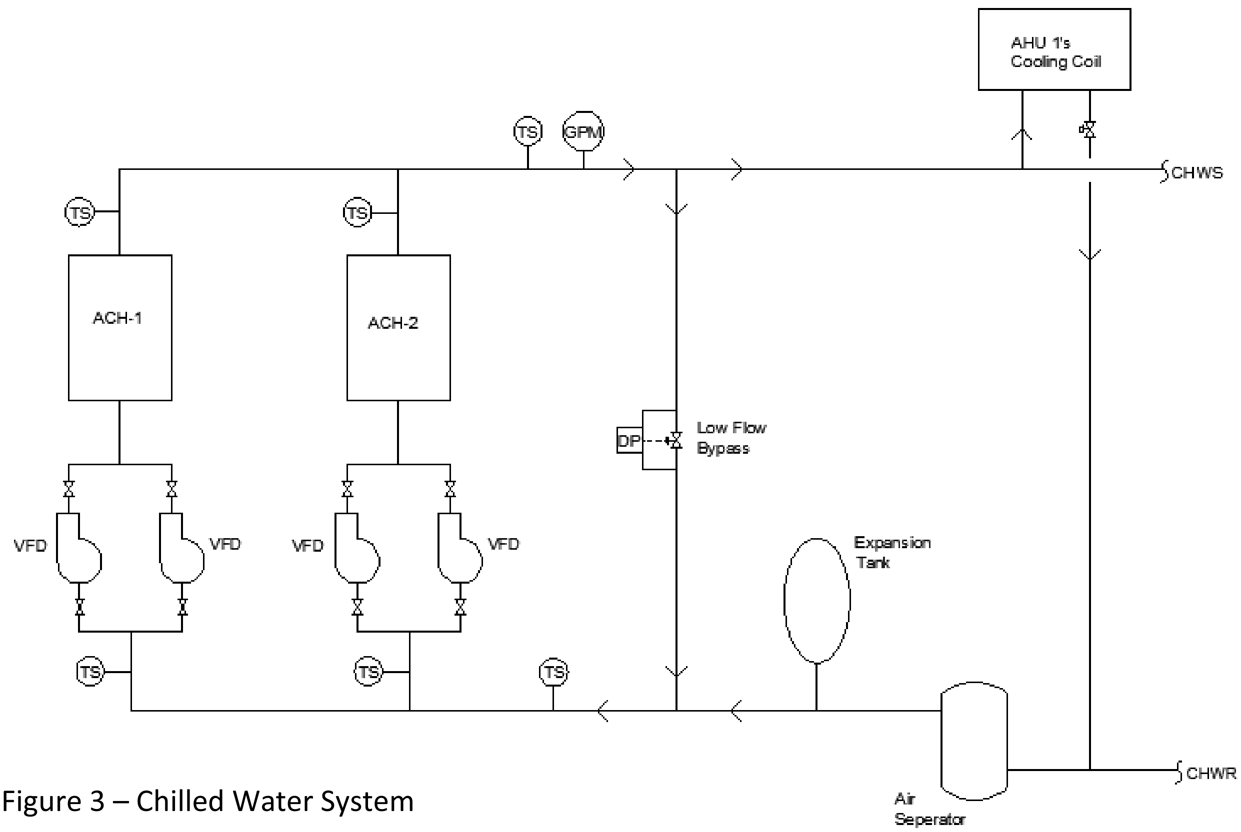

Figure 3 – Chilled Water System

Hot Water System

Natural gas is piped in through the gas meter in the Gas Room on the first floor. It is then piped up through the building to the boilers in the mechanical penthouse. The boilers, air separator, expansion tank, and pumps for the hot water system are all located in the mechanical penthouse. The four natural gas fired, condensing boilers can produce 1860 MBH each of 35% propylene glycol – water mixture. The three hot water circulating pumps have variable frequency drives (one pump is used for stand by). The pumping system is variable primary flow with a bypass line. The bypass line is controlled by a differential pressure sensor. The hot propylene glycol – water mixture is supplied at 140°F to the AHU's heating coils, fin tube radiators, cabinet heaters, and unit heaters. The solution is returned at 120°F giving a ΔT of 20°F for heating. Check valves control flow through the boilers and pumps. An air separator and expansion tank are located on the supply side. The hot water system can be seen below in Figure 4.

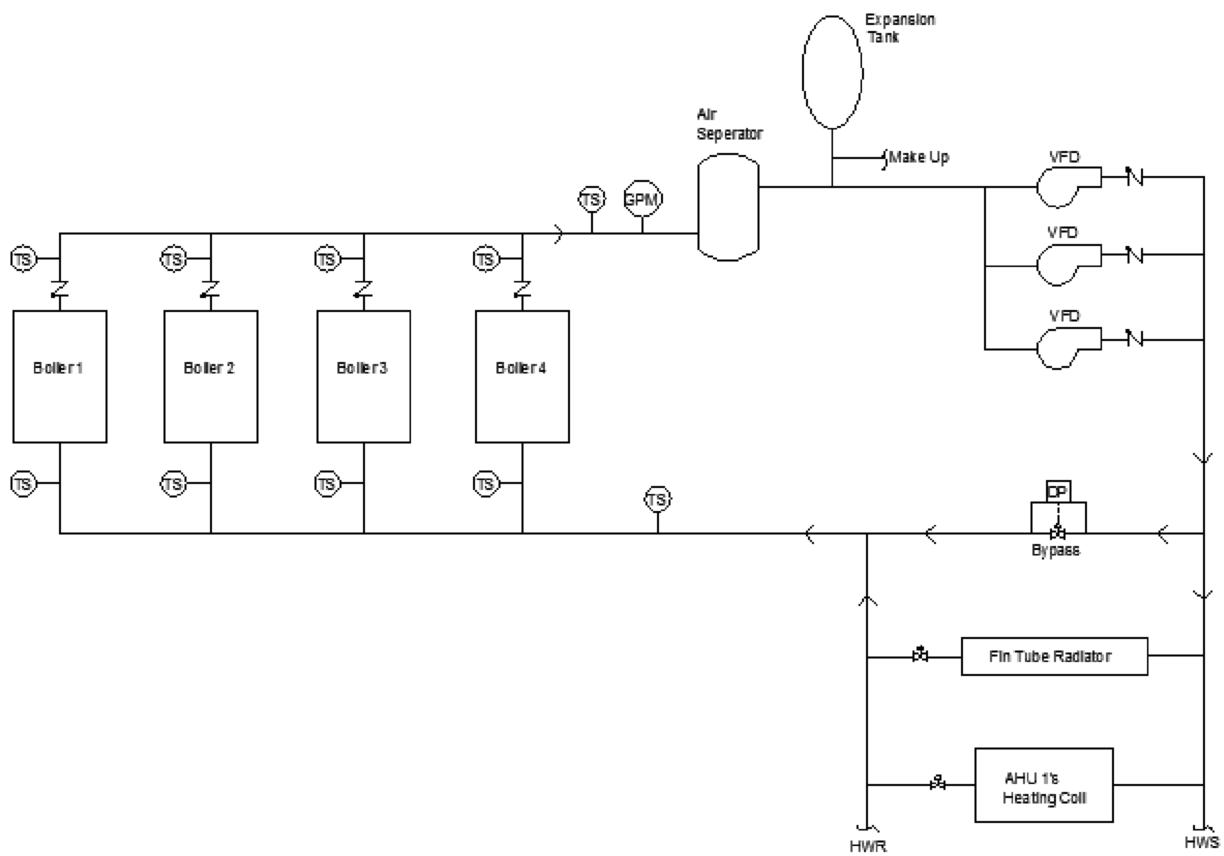

Figure 4 – Hot Water System

Lost Usable Space

Mechanical equipment as well as duct runs require floor space and detract from the overall usable building area. Below in Table 15 is a breakdown of the floor space used by the mechanical equipment.

The Fuel Oil Room feeds the emergency generator and the Gas Room supplies the boilers with natural gas. Space is lost on each floor from ducts that run between floors. This lost area is found under the "Shafts" breakdown. The "Penthouse" is located on the roof and includes the emergency generator, boiler, and mechanical storage rooms. Pumps and expansion tanks are located in the Boiler Room. "Penthouse" area is not included in the overall lost usable space because it is not considered usable space. This information was included to reflect how much actual space the mechanical systems occupy. Furthermore, lost usable space is saved by the air handlers and chillers being located on the roof. Hunter's Point South School has no basement.

The floor area lost to electrical and plumbing systems is not included in this breakdown. Further floor area is lost to these two systems.

Lost Usuable Space		
Space Type	Location (Floor)	Floor Area (square feet)
Fuel Oil Room	1st	132
Gas Room	1st	120
Shafts	2nd-5th	1429
Mechanical Penthouse	Roof	1924*
	Total	1681
	*Note: Not included in total.	

Table 15 – Lost Usable Space

Mechanical Equipment First Cost

The total cost of the mechanical equipment for Hunter's Point South School is $7,750,000. This equates to $50.40 per square foot of the building. The price includes furnish and installation of all the outlined equipment. Table 18 below has a breakdown of the cost for the different mechanical systems. To further clarify what each system encompasses, read below the table.

Mechanical Cost Breakdown		
Type	Cost ($)	Cost per square foot ($/sf)
AHU's	1,190,000	7.74
Chillers	820,000	5.33
Boilers	260,000	1.69
Heat Pumps	49,000	0.32
Fin Tube Radiators	300,000	1.95
Unit/Cabinet Heaters	143,000	0.93
VAV Boxes	216,000	1.40
Fan Powered Boxes	16,000	0.10
HVAC Piping	1,250,000	8.13
Ducts	1,479,500	9.62
HVAC Controls	910,000	5.92
Pumps	32,000	0.21
Convectors	14,000	0.09
Fans	80,000	0.52
Dampers	55,000	0.36
Diffusers/Grills	100,000	0.65
Emergency Generator/Fuel Oil	182,000	1.18
Glycol	35,000	0.23
Miscellaneous	38,500	0.25
Overhead	580,000	3.77
Total	**7,750,000**	**50.40**

Table 16 – Mechanical Cost Breakdown

- The Boilers cost includes the chemical treatment as well as the boilers.
- The HVAC Piping includes all piping for the HVAC equipment. This includes piping to and from the equipment, anchors/guides, and insulation. The plumbing piping is not included in this number.
- Ducts cost include insulation, silencers, and all supply and return duct runs.
- The HVAC Controls include all the controls needed to run the different mechanical equipment and systems. Pressure valves are also included here.
- Fans include the 12 rooftop and 10 in-line exhaust fans. The fans in the AHU's and chillers' condensers are not included here, rather in their respective tab.
- The Emergency Generator/Fuel Oil includes all costs associated with this system. This includes piping, controls, pump set, tank, generator, and ducts.
- Miscellaneous includes the cost of the seismic restraint, hot water pumps' inertia pads, and the hot and cold make up water.
- Overhead includes the cost of the site project supervisor, project management, commissioning/punch lists, shop drawings, and submittals.

LEED Rating System

The LEED rating system is not followed by Hunter's Point South School. This is because it follows the New York City Green School Guide. This guide is outlined very similar to LEED and is required for new schools in New York City. The attempt is to make these school houses more sustainable and green. Thus, Hunter's Point South School is very environmentally conscious but will not strive for any LEED status or even certification.

The NYC Green School Guide is based very much on the USGBC's LEED rating system. Many of the points for both systems overlap. Because of this, the analysis of the LEED rating system was still done and is outlined below for the mechanical systems of Hunter's Point South School.

Energy & Atmosphere

EA Prerequisite 1: Fundamental Commissioning of the Building

(Required)

Intent – Verify that the building's energy related systems are installed, calibrated and perform according to the owner's project requirements, basic of design, and construction documents.

Execution – Upon completion of work, a test shall be conducted in the presence and under direction of a licensed professional engineer or registered architect (retained by the contractor) who is qualified to run such tests. These tests shall show compliance with the code requirements for ventilation and proper operation of the HVAC devices.

EA Prerequisite 2: Minimum Energy Performance

(Required)

Intent – Establish the minimum level of energy efficiency for the proposed building and systems.

Execution – Hunter's Point South School complies with Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 of ASHRAE Standard 90.1-2007 and from the building model ran by the design engineers there is a 28.3% reduction in yearly energy cost from the baseline building of ASHRAE Standard 90.1-2007 Appendix G.

EA Prerequisite 3: Fundamental Refrigerant Management

(Required)

Intent – Reduce ozone depletion.

Execution – No CFC-based refrigerants are used. The chillers and heat pumps use R-410a as a refrigerant.

EA Credit 1: Optimize Energy Performance

(6 of 10 Points)

Intent – Achieve increasing levels of energy performance above the baseline in the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

Execution – Following Appendix G of ASHRAE Standard 90.1-2007, Hunter's Point South School will save 28.3% in yearly energy cost over the base building. Since Hunter's Point South School is a new building it has stricter requirements and will only receive 6 out of the possible 10 points.

EA Credit 2: On-Site Renewable Energy

(0 of 3 Points)

Intent – Encourage and recognize increasing levels of on-site renewable energy self-supply in order to reduce environmental and economic impacts associated with fossil fuel energy use.

Execution – No energy is generated from on-site renewable energy sources.

EA Credit 3: Enhanced Commissioning

(0 of 1 Point)

Intent – Begin the commissioning process early during the design process and execute additional activities after systems performance verification is completed.

Execution – The commissioning for Hunter's Point South School does not begin until the construction phase. No input is gathered from the commissioners during the design phase.

EA Credit 4: Enhanced Refrigerant Management

(1 of 1 Point)

Intent – Reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to global warming.

Execution – Following Option 2, a value of 44.4 was calculated for the weighted average atmospheric impact due to the chillers and heat pumps. This is lower than the bar set at 100 by LEED and therefore complies.

EA Credit 5: Measurement & Verification

(0 of 1 Point)

Intent – Provide for the ongoing accountability of building energy consumption over time.

Execution – No plans could be found to outline such a program being set forth.

EA Credit 6: Green Power

(1 of 1 Point)

Intent – Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

Execution – Hunter's Point South will use 360,703 kWh per year of allocated green power for 2 years. This is above the 35% building's electricity from renewable sources required by this credit.

Indoor Environmental Quality

EQ Prerequisite 1: Minimum IAQ Performance

(Required)

Intent – Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

Execution – Hunter's Point South School follows both ASHRAE Standard 62.1 Section 6 and the New York City Mechanical Code for minimum ventilation.

EQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control

(Required)

Intent – Minimize exposure of building occupants, indoor surfaces, and ventilation air distribution system to Environmental Tobacco Smoke (ETS).

Execution – No smoking is allowed in Hunter's Point South School and smoking areas outside of the building are located far enough away as to comply with this prerequisite.

EQ Credit 1: Outdoor Air Delivery Monitoring

(1 of 1 Point)

Intent – Provide capacity for ventilation system monitoring to help sustain occupant comfort and well-being.

Execution – CO_2 sensors are located in spaces of high occupancy. VAV boxes are controlled to distribute at least the minimum amount of outside air required. This credit is attainable.

EQ Credit 2: Increased Ventilation

(0 of 1 Point)

Intent – Provide additional outdoor air ventilation to improve indoor air quality for improved occupant comfort, well-being and productivity.

Execution – From technical report one, all constant air volume AHU's meet the above 30% minimum rates. However, the variable air volume AHU's do not meet this requirement. This credit is not attainable unless the minimum supplied fraction on the VAV boxes is ramped up.

EQ Credit 3.1: Construction IAQ Management Plan: During Construction

(1 of 1 Point)

Intent – Reduce indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.

Execution – The construction methods comply with the SMACNA (Sheet Metal and Air Conditioning National Contractors Association) and filters are required to have a MERV of 8 during construction for return air grilles.

EQ Credit 3.2: Construction IAQ Management Plan: Before Occupancy

(1 of 1 Point)

Intent – Reduce indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.

Execution – Through Option 1, a flush-out of Hunter's Point South School will occur prior to occupancy. It is up to the owner to determine which type of flush-out to use.

EQ Credit 4.1: Low-Emitting Materials: Adhesives & Sealants

(1 of 1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – Adhesives and sealants used fall below the VOC limits outlined in this credit. Hunter's Point South School was designed with low VOC emission in mind.

EQ Credit 4.2: Low-Emitting Materials: Paints & Coatings

(1 of 1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – Paints and coatings used fall below the VOC limits outlined in this credit.

EQ Credit 4.3: Low-Emitting Materials: Carpet Systems

(1 of 1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – Carpets installed meet the necessary requirements and adhesives used fall below the VOC limits outlined.

EQ Credit 4.4: Low-Emitting Materials: Composite Wood & Agrifiber Products

(1 of 1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – Composite wood and agrifiber products do not use any urea-formaldehyde resins. This credit is attainable.

EQ Credit 5: Indoor Chemical & Pollutant Source Control

(1 of 1 Point)

Intent – Minimize exposure of building occupants to potentially hazardous particulates and chemical pollutants.

Execution – Vestibules are used at all the main entrances to Hunter's Point South School which have dimensions greater than six feet in the direction of travel. Fume hoods are used to control any pollutant sources created in the laboratories.

EQ Credit 6.1: Controllability of Systems: Lighting

(1 of 1 Point)

Intent – Provide a high level of lighting system control by individual occupants or by specific groups in multi-occupant spaces (i.e. classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.

Execution – Over 90% of the lights in Hunter's Point South School are controllable by building occupants. Thereby this credit is attainable.

EQ Credit 6.2: Controllability of Systems: Thermal Comfort

(1 of 1 Point)

Intent – Provide a high level of thermal comfort system control by individual occupants or by specific groups in multi-occupant spaces (i.e. classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.

Execution – Operable windows and accessible thermostats are provided in the majority of rooms. VAV boxes specifically serve one space each for better comfort control.

EQ Credit 7.1: Thermal Comfort: Design

(1 of 1 Point)

Intent – Provide a comfortable thermal environment that supports the productivity and well-being of building occupants.

Execution – The HVAC systems and building envelope of Hunter's Point South Building were designed to meet ASHRAE Standard 55. This credit shall be earned.

EQ Credit 7.2: Thermal Comfort: Verification

(0 of 1 Point)

Intent – Provide for the assessment of building thermal comfort over time.

Execution – Verification of thermal comfort is not needed in the NYC Green School Guide. Therefore there this credit will not be obtained.

EQ Credit 8.1: Daylight & Views: Daylight 75% of Spaces

(1 of 1 Point)

Intent – Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Execution – Through the calculation of Option 1, Hunter's Point South School will obtain this credit.

EQ Credit 8.2: Daylight & Views: Daylight 90% of Spaces

(1 of 1 Point)

Intent – Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Execution – The majority of rooms in Hunter's Point South School are located along the exterior and thus have direct views outside. The rooms congregated in the middle of the school that don't have views are generally unoccupied rooms or rooms of short occupancy duration. Because of this, Hunter's Point South School has views in at least 90% of all regularly occupied spaces.

Overall System Evaluation

The mechanical system for Hunter's Point South School meets the requirements outlined for design. The total mechanical system cost was $7,750,000 which is approximately $50.40 per square foot. Two of the biggest cost factors were the ductwork and custom made air handling units. Operating the mechanical system would cost $294,212 a year or $1.91 a square foot. Space was saved by placing the mechanical equipment on the roof but extensive ductwork was still required. A total of 1,681 square feet were lost to the mechanical system, the most of it being shafts for ducting from floor to floor.

The variable and constant flow AHU's meet the ventilation requirements outlined in ASHRAE Standard 62.1. The VAV terminal boxes further help to save energy costs, however at times of full turndown ventilation requirements may not be met. Since the ductwork and AHU's consume such a huge percent of the total mechanical system cost, perhaps a hydronic system with a dedicated outside air system could be used instead. This would use smaller ductwork and ventilation requirements would be more easily met. In using smaller ducts, floor area would be saved because the vertical shafts would not need to be as big.

The evaluation for maintenance for the mechanical systems is mixed. Huge clearances are given around the AHU's as well as access doors. Chillers are easily reachable on the roof. All proponents of the system are very accessible but no elevator goes up to the mechanical penthouse or roof. Replacement of larger parts would be difficult. The only way to access the chillers, AHU's, boilers, and generator is by using the stairs.

Fume hoods do an excellent job to remove hazardous chemicals from the laboratories and science classrooms. However this energy is wasted. No heat recovery is used in Hunter's Point South School for any of the exhaust fans. Recovering exhausted heat can help save building energy costs.

Moving forward, the mechanical system designed for Hunter's Point South School is very good but not flawless. Heat recovery is not present at all. The use of roof space for mechanical equipment saves usable floor space but the use of a 100% outside air system with hydronic heating and cooling could potentially save more floor space. From reviewing the construction site, a large body of water is nearby but it is probably not close enough to be used effectively for geothermal. Looking forward there are a few promising leads to improve the efficiency of the mechanical systems of Hunter's Point South School.

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Appendix A – Minimum Ventilation Calculation

AHU-1

Room No.	Room Name	Occupancy Type	Area (sf)	Rp (cfm/person)	Ra (cfm/sf)	Pz	Vbz (cfm	Ez	Voz (cfm	Vpz (cfm	Zp	Evz
141	CustodianStorage	Storage Rooms	401	0	0.12	0	49	0.8	62	135	0.46	1.10
101/103	Is Project Room	Classrooms (age 9 plus)	1412	5	0.12	70	520	0.8	650	1240	0.52	1.04
105	Is Art	Art Classroom	1088	10	0.018	54	560	0.8	700	960	0.73	0.83
109A	Supervisor	Office Space	270	5	0.06	2	27	0.8	34	100	0.34	1.22
	Corridor 1st Floor West	Corridors	2800	0	0.06	0	168	0.8	210	230	0.91	0.65
246	Medical Suite	Daycare sickroom	702	10	0.18	6	187	0.8	234	230	1.02	0.55
241	Custodian Shop	Break Rooms	364	5	0.06	3	37	0.8	47	125	0.38	1.19
207B	Storage	Storage Rooms	104	0	0.12	0	13	0.8	17	34	0.50	1.06
205A	Office Work Room	Office Space	331	5	0.06	3	35	1	35	59	0.59	0.97
207	Staff Development/Literacy Coacl	Conference/meeting	954	5	0.06	47	293	0.8	367	620	0.59	0.97
207A	Office	Office Space	77	5	0.06	1	10	0.8	13	45	0.29	1.27
205B	A/V Storage	Storage Rooms	89	0	0.12	0	11	1	11	12	0.92	0.65
205C	Tech Center	Computer lab	412	10	0.12	10	150	0.8	188	200	0.94	0.62
205	Library	Libraries	3883	5	0.06	48	473	0.8	592	1170	0.51	1.06
242	Physical Therapy	Health club/aerobics	477	20	0.06	4	109	1	109	105	1.04	0.52
206	Office	Office Space	203	5	0.06	2	23	0.8	29	35	0.83	0.73
209	Cw - Activities for Daily Living	Classrooms (age 9 plus)	500	10	0.12	12	180	0.8	225	235	0.96	0.61
	Corridor 2nd Floor South	Corridors	1230	0	0.06	0	74	0.8	93	125	0.74	0.82
308A	Meeting Room	Conference/meeting	133	5	0.06	6	38	1	38	160	0.24	1.33
301	Is Classroom	Classrooms (age 9 plus)	684	10	0.12	34	423	0.8	529	550	0.96	0.60
303	Is Classroom	Classrooms (age 9 plus)	684	10	0.12	34	423	0.8	529	550	0.96	0.60
305	Is Classroom	Classrooms (age 9 plus)	688	10	0.12	34	423	0.8	529	550	0.96	0.60
307	Records	Storage Rooms	208	0	0.12	0	25	1	25	100	0.25	1.31
311	Gen Office	Office Space	494	5	0.06	5	55	0.8	69	190	0.36	1.20
315	Principal	Office Space	394	5	0.06	3	39	0.8	49	100	0.49	1.07
309A	Waiting	Reception areas	144	5	0.06	6	39	1	39	67	0.58	0.98
309	Mail	Office Space	288	5	0.06	2	28	1	28	35	0.80	0.76
	Corridor 3rd Floor West	Corridors	1350	0	0.06	0	81	0.8	102	135	0.76	0.81
401	Hs Classroom	Classrooms (age 9 plus)	680	10	0.12	34	422	0.8	528	550	0.96	0.60
403/405	Hs Classroom	Classrooms (age 9 plus)	1400	10	0.12	68	848	0.8	1060	1100	0.96	0.60
407	Records	Storage Rooms	208	0	0.12	0	25	1	25	100	0.25	1.31
411	Gen Office	Office Space	494	5	0.06	5	55	0.8	69	99	0.70	0.87
415	Principal	Office Space	394	5	0.06	2	34	0.8	43	100	0.43	1.13
311A	Copy	Office Space	144	5	0.06	1	14	0.8	18	41	0.44	1.12
411A	Copy	Office Space	144	5	0.06	1	14	0.8	18	21	0.86	0.71
409	Mail	Office Space	288	5	0.06	2	28	1	28	35	0.80	0.76
409A	Waiting	Reception areas	144	5	0.06	6	39	1	39	67	0.58	0.98
	Corridor 4th Floor West	Corridors	1350	0	0.06	0	81	0.8	102	135	0.76	0.81
524	Hs Receiving	Office Space	428	5	0.06	1	31	0.8	39	83	0.47	1.09
522	Hs Receiving Vestibule	Reception areas	386	5	0.06	2	34	0.8	43	103	0.42	1.15
518/518A/518B	Hs Guidance College	Office Space	372	5	0.06	3	38	0.8	48	100	0.48	1.08
516/516A/516B	Hs Guidance Office	Office Space	489	5	0.06	5	55	0.8	69	200	0.35	1.22
	Corridor 5th Floor East	Corridors	1800	0	0.06	0	108	0.8	135	200	0.68	0.89
508	Hs Supervisory	Office Space	224	5	0.06	2	24	1	24	60	0.40	1.16
506	Mediation	Conference/meeting	99	5	0.06	4	26	1	26	40	0.65	0.91
245	Office	Office Space	164	5	0.06	2	20	0.8	25	100	0.25	1.31
308B	Guidance Room	Office Space	250	5	0.06	2	25	1	25	160	0.16	1.41
						526	6414			11391		
			AHU-1				Vou ^			Vps ^		
		actual	min oa intake (cfm):		14945							
		actual	max supply (cfm):		30000					Xs =	0.56308	
			minimum oa fraction AHU can		0.50							
				Ev=	0.52	System Ventilation Efficiency						
				Vot=	12218							
				30%above	15883							

AHU-2

Room No.	Room Name	Occupancy Type	Area (sf)	Rp (cfm/person)	Ra (cfm/sf)	Pz	Vbz (cfm)	Ez	Voz (cfm	Vpz (cfm)	Zp	Evz	
113/115	Is & Hs Parents Meeting Room	Conference/meeting	802	5	0.06	10	99	0.8	124	270	0.46	1.18	
126A, 126C, L1C	Furniture Storage, Vault W. Anteroom, Vestibu	Storage Room	474	0	0.12	0	57	0.8	72	150	0.48	1.16	
119	Custodial Office	Office Space	314	5	0.06	3	34	1	34	100	0.34	1.30	
116	School Safety Office/Locker Rooms	Office Space	479	5	0.06	3	44	0.8	55	100	0.55	1.09	
118, 120	Is Receiving/General Supply Room	Office Space	519	5	0.06	5	57	0.8	72	100	0.72	0.92	
	Corridor 1st Floor East	Corridors	1060	0	0.06	0	64	1	64	100	0.64	1.00	
213/215/219/221	Special Education Classroom	Classrooms (age 9 plus)	1888	10	0.12	100	1227	0.8	1534	1600	0.96	0.68	
217	Special Education Clasroom	Classrooms (age 9 plus)	500	10	0.12	25	310	0.8	388	400	0.97	0.67	
225	Special Education Clasroom	Classrooms (age 9 plus)	659	10	0.12	31	390	0.8	488	510	0.96	0.69	
226	Special Education Clasroom	Classrooms (age 9 plus)	505	10	0.12	25	311	0.8	389	375	1.04	0.61	
224	Special Education Clasroom	Classrooms (age 9 plus)	530	10	0.12	26	324	0.8	405	425	0.95	0.69	
222	Hs Book Storage	Storage Room	489	0	0.12	0	59	0.8	74	113	0.65	0.99	
220	Classroom Speech	Classrooms (age 9 plus)	190	10	0.12	9	113	1	113	148	0.76	0.88	
218	Classroom Speech	Classrooms (age 9 plus)	190	10	0.12	9	113	1	113	148	0.76	0.88	
216	Is Book Storage	Storage Room	489	0	0.12	0	59	0.8	74	113	0.65	0.99	
214	Is Audio/Video Security Storage Room	Storage Room	361	0	0.12	0	44	0.8	55	65	0.85	0.80	
	Corridor 2nd Floor East	Corridors	1450	0	0.06	0	87	1	87	145	0.60	1.04	
318	Is Music	Classrooms (age 9 plus)	536	10	0.12	27	335	0.8	419	405	1.03	0.61	
320	Is Resource	Classrooms (age 9 plus)	323	10	0.12	16	199	0.8	249	260	0.96	0.68	
322	Is Resource	Classrooms (age 9 plus)	311	10	0.12	15	188	0.8	235	245	0.96	0.68	
	Corridor 3rd Floor East	Corridors	830	0	0.06	0	50	1	50	100	0.50	1.14	
324	Is Classroom	Classrooms (age 9 plus)	726	10	0.12	34	428	0.8	535	555	0.96	0.68	
325	Is Special Education	Classrooms (age 9 plus)	467	10	0.12	23	287	0.8	359	375	0.96	0.69	
323	Is Science Lab	Science Laboratories	903	10	0.18	30	463	0.8	579	600	0.97	0.68	
321	Is Science Prep	Science Laboratories	374	10	0.18	1	78	0.8	98	1200	0.08	1.56	
319	Is Science Lab	Science Laboratories	900	10	0.18	30	462	0.8	578	600	0.96	0.68	
317	Is Classroom	Classrooms (age 9 plus)	726	10	0.12	36	448	0.8	560	580	0.97	0.68	
	Corridor 4th Floor East	Corridors	830	0	0.06	0	50	1	50	100	0.50	1.14	
417/419/421	Hs Classroom	Classrooms (age 9 plus)	2022	10	0.12	102	1263	0.8	1579	1650	0.96	0.69	
423/425	Hs Classroom	Classrooms (age 9 plus)	1415	10	0.12	70	870	0.8	1088	1130	0.96	0.68	
424	Hs Classroom	Classrooms (age 9 plus)	685	10	0.12	34	423	0.8	529	550	0.96	0.68	
422	Hs Resource	Classrooms (age 9 plus)	356	10	0.12	17	213	0.8	267	280	0.95	0.69	
420	Hs Music Storage	Storage Room	383	0	0.12	0	46	0.8	58	69	0.84	0.80	
418	Hs Music	Classrooms (age 9 plus)	465	10	0.12	23	286	0.8	358	367	0.98	0.67	
517	Hs Special Education	Classrooms (age 9 plus)	468	10	0.12	23	287	0.8	359	185	1.94	-0.30	not used
519	Hs Science Lab	Science Laboratories	1261	10	0.18	38	607	0.8	759	1300	0.58	1.06	
521	Science Prep	Science Laboratories	501	10	0.18	5	141	0.8	177	1200	0.15	1.49	
523	Science Lab Demo	Science Laboratories	996	10	0.18	30	480	0.8	600	625	0.96	0.68	
525	Science Lab Demo	Science Laboratories	1010	10	0.18	30	482	0.8	603	630	0.96	0.69	
						830	11478			17868			
			AHU-2				Vou ^			Vps ^			
		actual	min oa intake (cfm):		19445								
		actual	max supply (cfm):		31700					Xs =	0.64238		
			minimum oa fraction AHU can		0.61								
				Ev=	0.61	System Ventilation Efficiency							
				Vot=	18971								
				30% above	24662								

AHU-3

Room No.	Room Name	Occupancy Type	Area (sf)	Rp (cfm/person)	Ra (cfm/sf)	Pz	Vbz (cfm)	Ez	Voz (cfm)	Vpz (cfm)	Zp	Evz
361/359/357/355	Is Classroom	Classroom (age 9 plus)	2892	10	0.12	144	1788	0.8	2235	2320	0.96	0.74
353	Is Classroom	Classroom (age 9 plus)	780	10	0.12	39	484	0.8	605	630	0.96	0.74
351/349	Is Classroom	Classroom (age 9 plus)	1358	10	0.12	66	823	0.8	1029	1070	0.96	0.74
347	Is Special Education	Classroom (age 9 plus)	438	10	0.12	21	263	0.8	329	340	0.97	0.73
341	Is Staff Locker	Storage Room	280	0	0.12	0	34	0.8	43	180	0.24	1.46
	Corridor 3rd Floor South	Corridors	3125	0	0.06	0	188	0.8	235	325	0.72	0.98
461/459/457/455	Hs Classroom	Classroom (age 9 plus)	2944	10	0.12	144	1794	0.8	2243	2400	0.93	0.77
453	Hs Classroom	Classroom (age 9 plus)	780	10	0.12	39	484	0.8	605	630	0.96	0.74
451/449	Hs Classroom	Classroom (age 9 plus)	1360	10	0.12	66	824	0.8	1030	1070	0.96	0.74
447	Hs Special Education	Classroom (age 9 plus)	389	10	0.12	12	167	0.8	209	220	0.95	0.75
441	Hs Staff Locker	Storage Room	280	0	0.12	0	34	0.8	43	185	0.23	1.47
	Corridor 4th Floor South	Corridors	3125	0	0.06	0	188	0.8	235	325	0.72	0.98
	Corridor 5th Floor South	Corridors	1540	0	0.06	0	93	1	93	230	0.40	1.30
539/541	Men's & Women's Locker Rooms	Storage Room	170	0	0.12	0	21	0.8	27	110	0.25	1.45
545	Guidance Records	Office Space	165	5	0.06	1	15	0.8	19	45	0.42	1.28
547	Program Office	Office Space	235	5	0.06	2	25	0.8	32	155	0.21	1.49
549	Hs Store	Storage Room	260	0	0.12	2	32	0.8	40	100	0.40	1.30
551	Government & Club House	Office Space	474	5	0.06	6	59	0.8	74	200	0.37	1.33
552	Hs Art Room	Art Classroom	1051	10	0.18	52	710	0.8	888	925	0.96	0.74
						594	8026			11460		
			AHU-3				Vou ^			Vps ^		
		actual	min oa intake (cfm):		13210							
		actual	max supply (cfm):		27000					Xs =	0.70035	
			minimum oa fraction AHU can supply		0.49							
				Ev=	0.73	System Ventilation Efficiency						
				Vot=	10954							
				30% above	14240							

AHU-4

Room No.	Room Name	Occupancy Type	Area (sf)	Rp (cfm/person)	Ra (cfm/sf)	Pz (people)	Vbz (cfm)	Ez	Voz (cfm)	Vpz (cfm)	Zp
130/146	Competition Gymnasium	Multipurpose Assembly	8052	5	0.06	660	3784	1	3784	15040	0.25
130A	Gym Storage	Storage Rooms	366	0	0.12	0	44	1	44	180	0.24
106	Is Girls' Locker Room	Storage Rooms	345	0	0.12	0	42	1	42	350	0.12
108	Health Instructor's Office	Office Space	349	5	0.06	2	31	1	31	180	0.17
102	Is Boys' Locker Room	Storage Rooms	345	0	0.12	0	42	1	42	350	0.12
134	Hs Girls' Locker Room	Storage Rooms	470	0	0.12	0	57	1	57	420	0.14
144	Hs Boys' Locker Room	Storage Rooms	430	0	0.12	0	52	1	52	380	0.14
145	Visitor Team's Locker Room	Storage Rooms	270	0	0.12	0	33	1	33	180	0.18
230/240	Auxiliary Exercise Room	Health Club/Aerobics Room	1900	20	0.06	38	874	1	874	2000	0.44
						Vou	4959				

	AHU-4	
actual	min oa intake (cfm):	13360
actual	max supply (cfm):	20860
	minimum oa fraction	0.64
	Vot=	7085
	30% above	9211

Max Zp =	0.44
Ev =	0.7

AHU-4

Room Number	Room Name	Design Ventillation	Minimum Ventilation	% Above Standard 62.1	Compliant With Standard	Above 30% (LEED)
130/146	Competition Gymnasium	9633	3784	255	Yes	Yes
130A	Gym Storage	115	44	262	Yes	Yes
106	Is Girls' Locker Room	224	42	534	Yes	Yes
108	Health Instructor's Office	115	31	372	Yes	Yes
102	Is Boys' Locker Room	224	42	534	Yes	Yes
134	Hs Girls' Locker Room	269	57	472	Yes	Yes
144	Hs Boys' Locker Room	243	52	468	Yes	Yes
145	Visitor Team's Locker Room	115	33	349	Yes	Yes
230/240	Auxiliary Exercise Room	1281	874	147	Yes	Yes

AHU-5												
Room No.	Room Name	Occupancy Type	Area (sf)	Rp (cfm/person)	Ra (cfm/sf)	Pz	Vbz (cfm)	Ez	Voz (cfm)	Vpz (cfm)	Zp	Evz
338/356	Is Café	Cafeteria/fast food-dining	2530	7.5	0.18	172	1746	1	1746	4920	0.35	0.96
534	Kitchen Complex	Cafeteria/fast food-dining	2174	7.5	0.18	16	512	1	512	3038	0.17	1.15
534C	Office 3	Office	125	5	0.06	1	13	1	13	75	0.17	1.14
534H	Food Storage	Storage	480	0	0.12	0	58	1	58	100	0.58	0.74
505/511	Hs Café	Cafeteria/fast food-dining	3150	7.5	0.18	210	2142	1	2142	5990	0.36	0.96
513, 515	Staff Dining & Servery	Cafeteria/fast food-dining	1027	7.5	0.18	8	245	1	245	600	0.41	0.91
536, 538	Men/Women Locker Room	Storage	320	0	0.12	0	39	1	39	250	0.16	1.16
534A	Can Wash	Storage	480	0	0.12	0	58	1	58	200	0.29	1.03
						Vou	4813			15173		
			AHU-5							Vpz ^		
		actual	min oa intake (cfm):		11840							
		actual	max supply (cfm):		18700					Xs =	0.317208	
			minimum oa fraction AHU can supply		0.63							
				Ev=	0.74	System Ventilation Efficiency						
				Vot=	6529							
				30% above	8488							

AHU-5						
Room Number	Room Name	Design Ventillation	Minimum Ventilation	% Above Standard 62.1	Compliant With Standard	Above 30% (LEED)
338/356	Is Café	3116	1746	178	Yes	Yes
534	Kitchen Complex	1924	512	376	Yes	Yes
534C	Office 3	48	13	369	Yes	Yes
534H	Food Storage	64	58	110	Yes	No
505/511	Hs Café	3793	2142	177	Yes	Yes
513	Staff Dining & Servery	380	245	155	Yes	Yes
536, 538	Men/Women Locker Room	159	39	408	Yes	Yes
534A	Can Wash	127	58	219	Yes	Yes

AHU-6

Room No.	Room Name	Occupancy Type	Area (sf)	Rp (cfm/person)	Ra (cfm/sf)	Pz	Vbz (cfm)	Ez	Voz (cfm)	Vpz (cfm)	Zp
338/356	Auditorium	Auditorium Seating Area	3844	5	0.06	366	2061	1	2061	7488	0.28
360	Dress Room	Storage Room	190	0	0.12	0	23	1	23	150	0.15
362	Dress Room	Storage Room	190	0	0.12	0	23	1	23	150	0.15
406	Projection Room	Telephone/Data Entry	117	5	0.06	2	18	1	18	140	0.13
						Vou	2125				

	AHU-6	
actual	min oa intake (cfm):	6325
actual	max supply (cfm):	9600
	minimum oa fraction AHU can supply	0.66
	Vot=	2657
	30% above	3454

Max Zp =	0.28
Ev =	0.8

AHU-6

Room Number	Room Name	Design Ventillation	Minimum Ventilation	% Above Standard 62.1	Compliant With Standard	Above 30% (LEED)
338/356	Auditorium	4934	2061	239	Yes	Yes
360	Dress Room	99	23	430	Yes	Yes
362	Dress Room	99	23	430	Yes	Yes
406	Projection Room	93	18	517	Yes	Yes