

**Martha's Vineyard
Regional High School
Vineyard Haven, MA**

2015

HVAC Systems Evaluation



Prepared For:

**Martha's Vineyard Regional School District
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EXECUTIVE SUMMARY

The Martha's Vineyard Regional High School was originally constructed in 1957 with major renovation/addition projects in 1978, 1992 and 1994 to comprise the current 140,000 square foot educational building.

Each renovation did not adequately carry forward the original system design parameters of the existing building resulting in systems that did not effectively support each other.

In addition, equipment has failed and has not either been repaired or replaced to provide the minimum necessary heating and ventilating requirements to several spaces.

The majority, if not all, of the HVAC equipment in the building has exceeded its expected operational life, is in various states of disrepair and is in need of replacement.

The Automatic Temperature Control system in particular is outdated and in a poor state of operation including several failed components which adversely affects the heating systems capabilities.

Some of the energy efficient measures incorporated into the building have also impacted the performance of the existing building systems.

The immediate recommendations for building system performance improvement, in order of priority, include the following:

1. Restore existing ventilation to the building unit ventilators including providing a new oil fired, storage type domestic hot water system, cleaning/flushing piping systems and replacement of existing hot water distribution pumps (8 total).

2. Replace unit ventilators including DDC controls, sized for future capacity of full air conditioning and ventilation.
3. Provide equipment and ventilation upgrades to the carpentry shop, automotive shop and culinary arts.
4. Provide ventilation and heating for all areas of the Guidance Office.
5. Provide ventilation, heating and air conditioning for all areas of the Principals Office Suite.
6. Providing differential pressure controls for hot water pumping systems.
7. Providing boiler lead/lag operation and hot water temperature reset based on outdoor air temperature.
8. Provide new head end direct digital control system for any new equipment and/or controls provided for immediate improvements to the system with capacity for expansion during for future long term renovations.

Longer term recommendations include the following:

1. Replacement of the entire HVAC system including mechanical equipment, revisions to the existing piping distribution system, automatic temperature controls and electrical to support the mechanical equipment.
2. Addition of air conditioning to the existing two pipe heating system.

BUILDING HVAC SYSTEMS

Heating, Ventilating and Air Conditioning

1957 Original Building

The original building was constructed in 1957 which encompasses G, H and J Wings in the key plan and consists of approximately 50,000 square feet of classroom, commercial kitchen, Cafeteria, Administration and common spaces.

The original building boiler room consisted of two oil fired, cast iron section boilers with building pumps that provided heating hot water through insulated hot water distribution piping to heating terminal equipment located throughout the building.

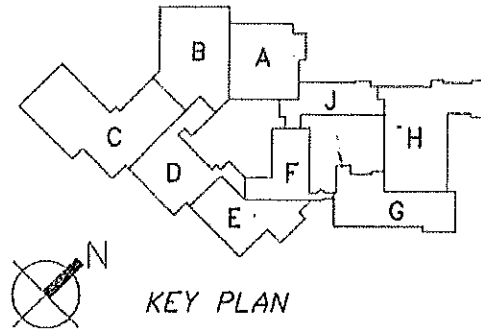
Fuel oil is provided by an underground fuel oil storage tank, duplex fuel oil pumpset and fuel oil piping.

Classrooms were provided with unit ventilators with face/bypass dampers controlled by wall mounted thermostats and a ducted exhaust with roof mounted exhaust fan systems.

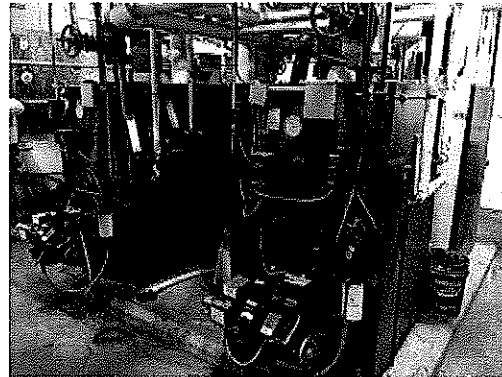
The Gymnasium was provided with hot water heating by radiation and unit heaters; ventilation was provided with fresh air intakes to the unit heaters.

The office areas were provided with hot water fintube radiation controlled by wall mounted thermostats and operable windows.

Miscellaneous areas were provided with general exhaust by ducted exhaust to roof mounted exhaust fans and heating by hot water terminal heating equipment (fintube



Martha's Vineyard Regional High School



1957 Building Boilers



1957 Building Indirect Domestic Hot Water Tank

radiation, hot water convectors, hot water unit heaters, hot water cabinet unit heaters, etc.).

1978 Building Renovation/Addition

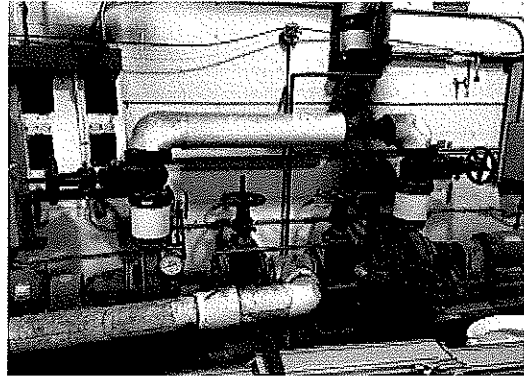
The 1978 Building Renovation/Addition project included renovating portions of the existing building including the boiler room and a new addition of E and F Wings in the key plan consisting of approximately 26,000 square feet of classrooms, Culinary Arts, Automotive Shop and Carpentry Shop.

At this time, the boiler room was renovated including replacing the boilers with two new boilers, each rated for 2,840 MBH gross output; adding new zone pumps (125 gpm at 66' TDH; 5 hp) and insulating hot water distribution piping for the heating terminal equipment in E and F Wings. The existing 1,000 gallon domestic hot water indirect tank and 1957 Building zone pumps remained as existing. The new equipment was sized for 210F supply water temperature.

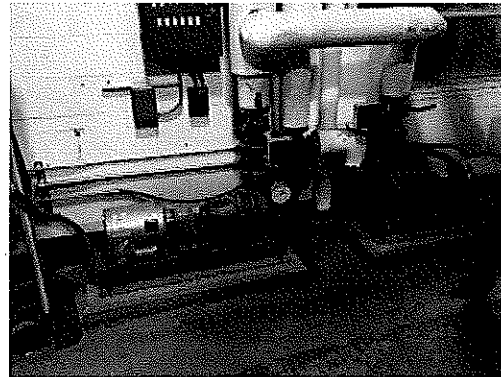
The Classrooms were provided with new unit ventilators and a ducted exhaust/roof mounted exhaust fan system sized for 5 CFM/Student ventilation.

The Culinary Arts was provided with kitchen hood exhaust by two roof mounted exhaust fans, untampered makeup air to each kitchen hood by rooftop makeup air units and space heating by rooftop heating and ventilating unit HV-3.

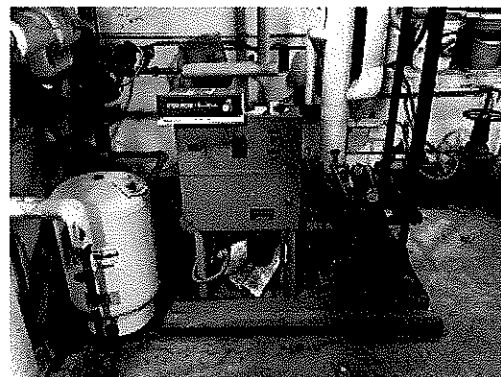
The Automotive Shop was provided with heating and ventilating by rooftop heating and ventilating unit HV-1; supplemental heat by a horizontal, hot water unit heater; an underground vehicle exhaust duct system interconnected to an inline exhaust fan; and general exhaust in adjacent storage rooms by



1957 Building Hot Water Pumps



1978 Building Hot Water Pumps



Fuel Oil Pumpset

a ducted exhaust system to an inline exhaust fan.

The Carpentry Shop was provided with heating and ventilating by rooftop heating and ventilating unit HV-2; supplemental heat by a horizontal, hot water unit heater; and general exhaust in adjacent storage rooms by a ducted exhaust system by an inline exhaust fan.

Miscellaneous areas were provided with general exhaust by ducted exhaust to roof mounted exhaust fans and heating by hot water terminal heating equipment (fintube radiation, hot water convectors, hot water unit heaters, hot water cabinet unit heaters, etc.).

Also at this time, the 1957 Building heating and ventilating equipment was rebalanced to a 5 CFM/person ventilation rate.

1992 Renovation

The Building Renovation project included renovating the Kitchen Cafeteria and creating a Healthcare Suite within G Wing in the key plan.

The Kitchen was provided with kitchen hood exhaust by a roof mounted exhaust fan, dishwasher exhaust by a roof mounted exhaust fan, and makeup air to the kitchen hood by a gas fired rooftop makeup air unit.

The Cafeteria was provided with a new air handling unit AHU-1 and duct distribution system controlled by a wall mounted thermostat.

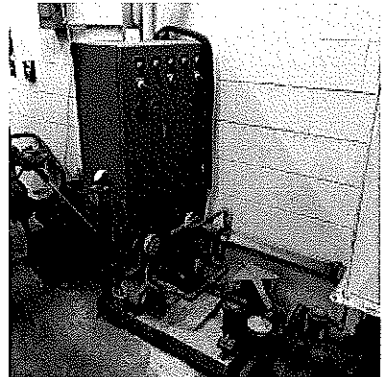
The former welding shop was renovated into the Healthcare Suite with hot water heating with fintube radiation at the exterior walls and heating/ventilating by air handling unit AHU-



1994 Addition Boilers



1994 Addition Hot Water Pumps



1994 Addition Fuel Oil Pumpset

2.

It should be noted that during this renovation, the new equipment was sized for 180F supply water temperature.

1994 Building Renovation/Addition

The 1994 Building Renovation/Addition project included renovating the entire existing building and a building addition of areas A, B, C and D Wings consisting of approximately 64,000 square feet of classroom, Auditorium, Gymnasium, Boiler Room and common spaces.

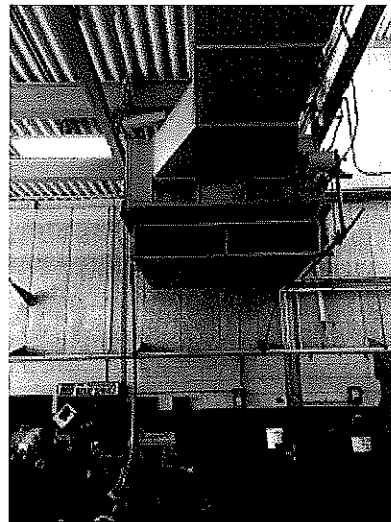
The new and renovated heating systems included new classroom unit ventilators, air handling units, rooftop air cooled condensing units (Auditorium, Auditorium Entry and Library), ductless split systems for various areas (Server Room, Offices, Etc.) and a new boiler room.

Classroom unit ventilators in the building addition were provided with a single control valve that controlled the classroom unit ventilator and the supplemental fin tube radiation behind the shelving at the exterior wall.

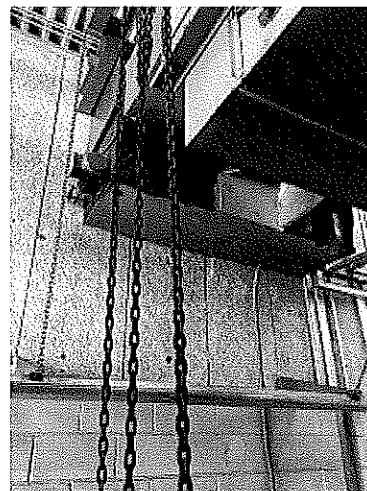
The boiler room included four new oil fired, cast iron sectional boilers for the building addition each rated for 1,446 MBH gross output; new hot water circulating pumps (625 gpm at 95' TDH; 25 hp) and insulating hot water distribution piping for the building heating terminal equipment; and dedicated zone pumps (125 gpm at 66' TDH; 5 hp) and insulated distribution piping for the Auditorium air handling unit AHU-3. The existing 1,000 gallon domestic hot water indirect tank in the 1957 Building was used to provide domestic hot water to the addition.



Covered Unit Ventilator Outdoor Intake Louvers



Automotive HV Unit (Inoperable)



Automotive HV Unit Intake Louver

The new equipment was sized for 180F supply water temperature.

Fuel oil is provided by an underground fuel oil storage tank, a duplex fuel oil pumpset and fuel oil piping.

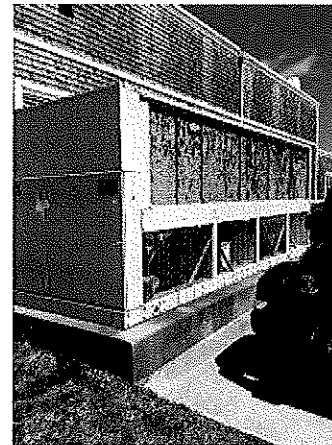
Note: The boilers in G Wing were shown as two existing boilers in the 1992 Renovation project and as four existing boilers in the 1994 Renovation/Addition project indicating they were replaced sometime between the two projects. The two former boilers with total gross output rated capacity of 5,780 MBH were replaced with four new boilers with indirect heaters for the domestic hot water tank and hot water heating with a total rated gross output capacity of 3,764 MBH.

As an addendum to the original design drawings, air conditioning was added to the project. The air conditioning project included two new air cooled chillers, 120 ton capacity for existing building and 80 tons for the building addition, that were intended to interconnect to a new two pipe heating/cooling system in the respective boiler rooms; new two pipe heating/cooling terminal equipment throughout the building and heating/cooling changeover controls.

The addendum changed the proposed new equipment and some of the original equipment that had previously been indicated to remain to new equipment with cooling capabilities; however, the piping that served existing equipment to be replaced was not addressed and would have been substantially undersized to support the new equipment, the proposed new ventilation requirements and new water flows required for heating/cooling. All equipment, except equipment in the F Wing and areas where DX cooling was to be



Dust Collector



Abandoned Chiller



Air Handling Unit 3-Way Valve

provided to the building, was replaced as indicated in the addendum.

The two new chillers were installed on their concrete equipment pads but never provided with the interconnecting piping from their installed location into the building and the classroom unit ventilators in F Wing were never replaced.

The automatic temperature controls consists of two separate systems with separate, outdated front ends. A McQuay system provides automatic temperature control to most of the building except for the air handling units and the unit ventilators in F Wing which are controlled by a Johnson system.

During recent years, the air handling units that served the Guidance and Principals suite failed and were replaced with ductless split systems.

At some point, the classroom unit ventilator intake louvers were boarded closed, eliminating all mechanical ventilation to the classrooms.

EVALUATION

Heating, Ventilating and Air Conditioning

The chillers were installed on the concrete pads but never interconnected to the building piping systems; at this point, the chillers should be considered inoperable.

The current mechanical ventilation to the school is deficient; even restoring the former ventilation capabilities to the classroom unit ventilators will not provide current code ventilation requirements and also reintroduces the probability of coil freeze failures.

Due to the significant downsizing of the boilers in the original building, restoring mechanical ventilation to their original design levels, the existing domestic hot water system should be removed from the hot water boilers to provide additional heating capacity to the building and be replaced with a separate oil fired, storage type hot water heating system.

To provide freeze protection to the heating systems, the introduction of a propylene glycol solution (30% propylene glycol solution would provide burst protection to -20F) would be required; however, the glycol solution would significant increase the viscosity of the system and would further aggravate an already poor system flow condition. In order to add propylene glycol to the system, it is recommended that the existing piping systems be cleaned/flushed and that new building circulating pumps be installed to accommodate the additional system head of the glycol solution.

At some point, the pumps were provided with variable speed drives controlled by return water temperature. Due to the unit ventilators with face/bypass dampers, air handling equipment with 3-way control valves, etc. this methodology is flawed since the water flow can't be properly controlled and will not allow for proper heating of the school; the pump variable speed drives control needs to be changed to differential pressure between the supply and return mains of each pumping system to properly control flow.

The boilers are manually controlled and not provided with a reset schedule based on outdoor air temperature leading to space overheating in several areas of the building due to ineffectual or inoperable controls; the

boilers should be provided with a control system that provides for lead/lag operation and hot water reset based on outdoor air temperature.

The Guidance suite air handling unit that failed and replaced by a ductless split systems does not provide adequate heating, air conditioning and ventilating to the spaces. In fact, there are two spaces within the suite that do not currently have any provisions for heating, air conditioning and ventilating. The Guidance suite should be provided with a new hot water heating, 5 ton DX cooling rooftop unit to provide heating, air conditioning and ventilating to the entire space.

The Principal suite air handling unit that failed and replaced by a ductless split systems does not provide adequate heating, air conditioning and ventilating to the spaces. In fact, there is a large conference room within the suite that does not currently have any provisions for heating, air conditioning and ventilating. The Principal suite should be provided with a new hot water heating, 5 ton DX cooling rooftop unit to provide heating, air conditioning and ventilating to the entire space.

The Automotive Shop heating and ventilating unit interlocked with the automotive exhaust system needs to be replaced with a new unit to provide proper space environment in accordance with applicable design standards.

The Carpentry Shop heating and ventilating unit interlocked with the dust collector exhaust system needs to be replaced with a new unit to provide proper space environment in accordance with applicable design standards.

The Sculpture Room heating and ventilating unit interlocked with the exhaust hoods system needs to be replaced with a new unit and new hood exhaust fans to provide proper space environment in accordance with applicable design standards.

In accordance with ASHRAE, the building HVAC equipment expected operational life is as follows:

Cast Iron Sectional Boilers	35 years
Base Mounted Pumps	20 years
Unit Ventilators	20 years
Air Handling Units	20 years
Air Cooled Condensing Units	20 years
Roof Exhaust Fans	15 years
Direct Digital Controls	15 years

The majority, if not all, of the HVAC equipment in the building has exceeded its expected operational life, is in various states of disrepair and is in need of replacement.

The Automatic Temperature Control system in particular is outdated and in a poor state of operation. Much of the McQuay system has failed and no longer has replacement parts available; the failed control valves in the building addition which control both the unit ventilators and supplemental fin tube radiation has been particularly problematic with space overheating issues.

While it is important to get the control strategies updated with a more user friendly and effective platform, it is not recommended to retrofit equipment that has exceeded its expected operational life with new controls. A new Building Energy Management System and new direct digital controls for any new equipment should be provided as part of any immediate renovations to the building.

RECOMMENDATIONS

Heating, Ventilating and Air Conditioning

Immediate recommendations, in order of priority, include the following:

1. Restore existing ventilation to the building unit ventilators including removing existing domestic hot water system from boiler hot water systems by providing two new oil fired, storage type domestic hot water system, cleaning/flushing piping systems and replacement of existing hot water distribution pumps (8 total) with pumps provided with adequate flow and pressure capacity for the systems which they serve.
ECC: \$150,000.00
2. Replace unit ventilators including DDC controls, sized for future capacity of full air conditioning and ventilation.
ECC: \$325,000.00
3. Provide equipment and ventilation upgrades to the carpentry shop, automotive shop, sculpture and culinary arts.
ECC: \$100,000.00
4. Provide ventilation and heating for all areas of the Guidance Office.
ECC: \$25,000
5. Provide ventilation, heating and air conditioning for all areas of the Principals Office Suite.
ECC: \$25,000
6. Providing differential pressure controls for hot water pumping systems. ECC: \$ 10,000.00
7. Providing boiler lead/lag operation and hot water temperature reset

based on outdoor air temperature.
ECC: \$15,000.00

8. Provide new head end direct digital control system for any new equipment and/or controls provided for immediate improvements to the system with capacity for expansion during for future long term renovations.
ECC: \$50,000.00

Longer term recommendations include the following:

1. Replacement of the entire HVAC system including mechanical equipment, revisions to the existing piping distribution system, automatic temperature controls and electrical to support the mechanical equipment.
ECC: \$4,200,00.00
2. Addition of air conditioning to the existing two pipe heating system.
ECC: \$600,000.00

Note: Incorporation of recommendations that will increase the ventilation to improve indoor air quality and providing freeze protection with the introduction of a propylene glycol solution into the heating hot water systems. will significantly increase the operating cost of school.

