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Executive Summary

The purpose of technical report one is to evaluate the 123 Alpha Drive Renovation to ensure that the building is in compliance with ASHRAE Standards 62.1-2010, Sections 5 and 6, and Standard 90.1-2010.

123 Alpha Drive was found to be fully compliant under the guidelines of ASHRAE Standard 62.1-2010. In conjunction with ten exhaust fans, six rooftop units met the minimum ventilation requirements for the building. The system controls were deemed to be compliant by using a seven day programmable thermostat and a contaminant detection system. Proper sealant of the building enclosure was found to be acceptable for the building type and use. ASHRAE Standard 62.1 specifies specific requirements for mold and bacterial prevention in different applicable spaces of the building. Recirculation procedures and guidelines such as contaminated air rejection and exhaustion are also ensured in the standard. Supply air intakes are designated to be a certain distance from exhaust equipment or system components that can be deemed as safe. These requirements are in place to ensure building occupant health and building performance.

The investigation and analysis of ASHRAE Standard 90.1-2010 indicated that 123 Alpha Drive was completely compliant. The various building envelope requirements were met by fenestration design and sufficient insulation used in the walls and roofs. The lighting power densities of the building were found to be compliant as well, mainly due to the use of high efficiency fluorescent lighting implemented throughout the various spaces. The pumping efficiency of the building systems was found to be adequate. A further investigation of many of these categories will be conducted in Technical Report Two.

Building Overview

123 Alpha Drive is an 80,000 square foot, office and warehouse building located on the campus of the Regional Industrial Development Corporation (RIDC) in Pittsburgh, PA. 123 Alpha Drive is a one story structure designed in order to manage various warehouse shipments and offer sufficient office space. Obtained by THAR Geothermal Incorporation in early 2011, the now serves as THAR's corporate headquarters and storage facility. The building is large enough to achieve adequate, storage and office space, while providing additional space purpose requirements such as laboratory areas and conference rooms. The façade of the structure is composed of primarily concrete masonry and brick sections, occasionally separated by large, retractable warehouse doors and typical 3'x5' rectangular window. The building was designed to achieve a high thermal mass within the walls of the building in order to compensate for the poor thermal resistivity properties of the large warehouse doors.

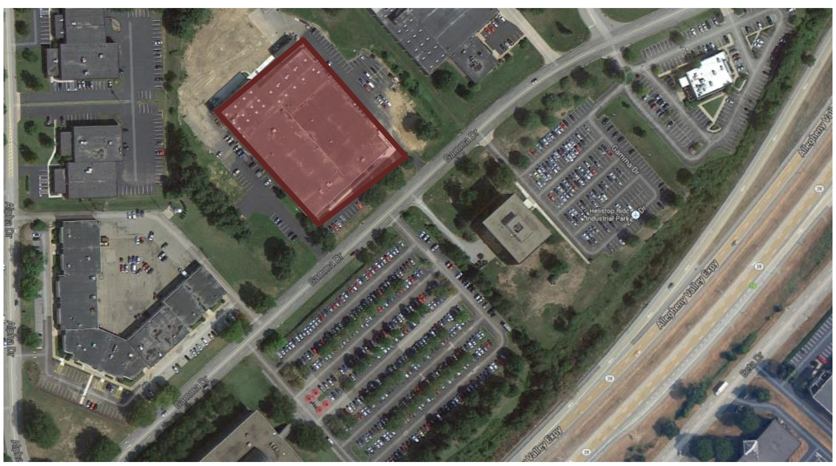

Figure 1: 123 Alpha Drive Location in RIDC Park and Allegheny County

Mechanical System Overview

Ventilation

123 Alpha Drive is ventilated using six small rooftop units (RTUs) and ten large horizontal air handling units. Figure 2, below, indicates the appropriate AHU zoning for the building. Four of the six rooftop units are existing to remain, but the newly installed RTU's have been selected in order to incorporate an outside air carbon dioxide preconditioned heating and cooling cycle, a technique utilized in the airline business. The liquid CO_2 preconditioning coil will be located in the outside air stream of the two units. The goal of this preconditioning is to achieve a lower 'delta T' at the final cooling and heating coils,

saving considerable energy throughout the unit's lifetime. Equipped with a full economizer each, the RTUs will provide efficient ventilation in the building, along with a considerable reduction in energy consumption. The units utilize gas heating and electric cooling. The following figure shows which air handling units and rooftop units service different areas of the building.

Lab and Contaminant Exhaust

Various warehouse and dry lab spaces within the building require lab air and contaminant exhaust. Ten small down-blast, roof-mounted exhaust fans with motorized dampers were installed to handle the exhaust air requirements. The air will be replenished by a 4-ton, existing to remain, make-up rooftop unit.

Radiant Floor Slab Cooling and Heating

In addition to the rooftop units supplying fresh air to the office and lab spaces, a hydronic radiant floor cooling and heating system has been implemented through "dry installation", in which the tubing is attached under the finished floor or subfloor. Utilizing an efficient fluid such as liquid carbon dioxide, the radiant floor slabs achieve a more efficient heating and cooling process than a ducted system, as no duct losses exist in a radiant system. A standard gas boiler is used as an energy source to heat the liquid within the tubes. Condensation is a considerable concern with radiant floor cooling, and will be explored throughout the course of this study.

Figure 2: Rooftop Unit Zoning Maps

ASHRAE Standard 62.1-2010 Analysis

Section 5: System and Equipment

5.1 Ventilation Air Distribution

123 Alpha Drive meets design ventilation requirements by section 6 of Standard 62.1. The ventilation are distribution system has the means to adjust system in order to accommodate for the minimum ventilation airflow required. Various air transfer ducts, rooftop units, and constant volume air handling units are used to help ventilate ground floor of the building. Detailed calculations for the ventilation air distribution system can be found in appendix A at the end of this report.

5.2 Exhaust Duct Location

All exhaust ducts carrying potentially harmful contaminates from toilet or janitor rooms have a minimum negative pressurization of 2-inch wg and a SMACNA seal class of C. The entire volume of exhaust is discharged at a safe distance above the roof. The dry lab spaces along the central corridor of the building contain exhaust systems that shall be in compliance with NFPA 45 and ANSI/AIHA Z9.5.

5.3 Ventilation System Controls

Each air handling unit and rooftop unit will be equipped with an Automatic Temperature control system123.This system consists of unoccupied and occupied operation modes that will control outside air dampers to ensure minimum ventilation requirements are met. The system is designed to maintain no less than the minimum outdoor airflow under any load condition as specified by Section 6.

5.4 Airstream Surfaces

Mold growth and erosion is avoided by using galvanized G90 steel sheet metal of SMACNA Pressure Class 1” that is in accordance of UL 181 ASTMC 1338 Standards.

5.5 Outdoor Air Intakes

Outside air intakes for all rooftop units are located above the rooftop level. Air handling unit outdoor air intakes are located at the roof level for each warehouse space. All outside air intakes have been located 15 feet or more from all exhaust outlets that exhaust lab air specified under NFPA 45 and ANSI/AIHA Z9.5 and Class 3 air originating toilet and janitor rooms. All intakes comply with ASHRAE Standard 62.1 Table 5-1 below. Specification requires that bird screens and storm proof louvers be implemented in an attempt to prevent the entry of precipitation. The require louver details that could assist in making this determination could not be found.

TABLE 5-1 Air Intake Minimum Separation Distance

Object	Minimum Distance, ft (m)
Class 2 air exhaust/relief outlet (Note 1)	10 (3)
Class 3 air exhaust/relief outlet (Note 1)	15 (5)
Class 4 air exhaust/relief outlet (Note 2)	30 (10)
Plumbing vents terminating less than 3 ft (1 m) above the level of the outdoor air intake	10 (3)
Plumbing vents terminating at least 3 ft (1 m) above the level of the outdoor air intake	3 (1)
Vents, chimneys, and flues from combustion appliances and equipment (Note 3)	15 (5)
Garage entry, automobile loading area, or drive-in queue (Note 4)	15 (5)
Truck loading area or dock, bus parking/idling area (Note 4)	25 (7.5)
Driveway, street, or parking place (Note 4)	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake (Notes 5 and 6)	1 (0.30)
Garbage storage/pick-up area, dumpsters	15 (5)
Cooling tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

Note 1: This requirements applies to the distance from the outdoor air intakes for one ventilation system to the exhaust/relief outlets for any other ventilation system.
Note 2: Minimum distance listed does not apply to laboratory fume hood exhaust air outlets. Separation criteria for fume hood exhaust shall be in compliance with NFPA 45[5] and ANSI/AIHA Z9.5.[6] Information on separation criteria for industrial environments can be found in the *ACGIH Industrial Ventilation Manual*[7] and in the *ASHRAE Handbook—HVAC Applications*.[8]
Note 3: Shorter separation distances shall be permitted when determined in accordance with (a) ANSI Z223.1/NFPA 54[9] for fuel gas burning appliances and equipment, (b) NFPA 31[10] for oil burning appliances and equipment, or (c) NFPA 211[11] for other combustion appliances and equipment.
Note 4: Distance measured to closest place that vehicle exhaust is likely to be located.
Note 5: Shorter separation distance shall be permitted where outdoor surfaces are sloped more than 45 degrees from horizontal or that are less than 1 in. (3 cm) wide.
Note 6: Where snow accumulation is expected, the surface of the snow at the expected average snow depth constitutes the "other surface directly below intake."

Figure 3: Table 5-1 ASHRAE 62.1-2010 Section 5

5.6 Local Capture of Contaminants

All contaminants that are generated by equipment are properly exhausted directly outside through a ducted run to avoid mixing into occupied spaces.

5.7 Combustion Air

123 Alpha Drive has condensing boilers located on the ground floor. The boilers are vented directly outside.

5.8 Particulate Matter Removal

Each air handling unit and packaged rooftop unit has been equipped to use pre-filters with a MERV 8 rating and a final filter with a MERV 13 rating upstream of the cooling coil. These filters comply with ANSI/ASHRAE Standard 52.2, which requires a minimum filtration rating of MERV 6.

5.9 Dehumidification Systems

A relative humidity of 50% has been elected as the desired and specified dehumidification capability throughout the building. The minimum supply air of the majority of the mechanical systems is greater than the maximum exhaust air, which in turn produces a positive pressurization for the majority of the building. The exfiltration requirements for 123 Alpha Drive have been met.

5.10 Drain Pans

The condensate drain pans have at least a ¼" per foot minimum slope toward the drain connection. All sizes have been specified to adequately collect from all cooling coils with a minimum depth of 2 inches deep. All other drain pans are to be designed and manufactured to according to ASHRAE Standard 62.1. A detail of a typical rooftop condensate drain can be seen in *Figure 4* below.

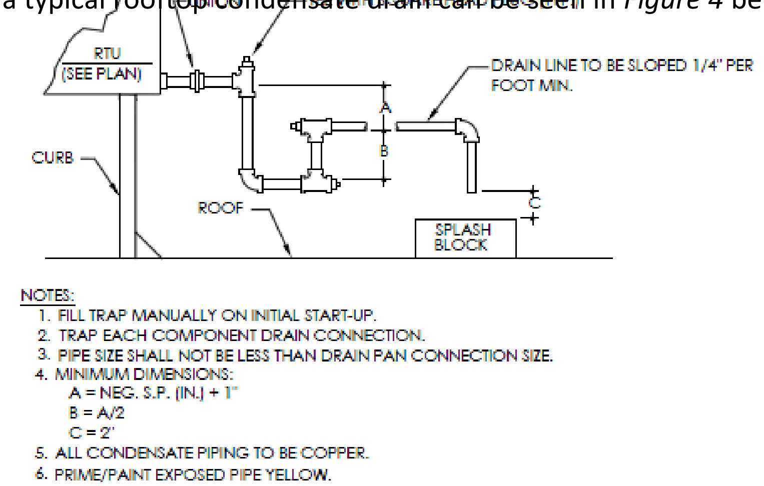

Figure 4: Condensate Drain Pan Detail

5.11 Finned-Tube Coils and Heat Exchangers

All finned-tube coils and heat exchangers have drain pans according to ASHRAE section 5.1. All Heat exchangers will have access doors at least 18 inches wide and are provided on both sides of coils.

5.12 Humidifiers and Water-Spray Systems

The water quality is such that the water used for humidification and water-spray systems originates directly from a portable source. No obstructions downstream of the humidifier, such as turning vanes, volume damps, or duct offsets greater than 15 degree, exist at a location shorter than the allowable distance. Therefore, 123 Alpha Drive complies with ASHRAE Standard 62.1 section 5.12.

5.13 Access for Inspection, Cleaning, and Maintenance

The following items will be provided access doors for various inspection, cleaning, and maintenance:

-Volume Dampers
-Fire Dampers
-Control Devices
-Packaged Rooftop Units
-Control Devices
-Air Handling Units
-Mixed-air plenums
-Humidifiers
-Fans

5.14 Building Envelope and Interior Surfaces

All exterior roofing and exterior walls have been specified to possess appropriate waterproofing. *Figure 6 & 7* indicate typical wall sections that exist within the building's structural system. A vapor retarder or barrier has been installed in the exterior wall systems in an attempt to avoid water penetration into the envelope. Condensation on cold surfaces such as concrete masonry units has been limited by the strategic placement of vapor barriers in the walls and roofs of the building. The many overhead doors that are components of the building envelope do not have the proper details or information included in the available drawing sets to determine if sufficient weather or vapor infiltration prevention is in. It will be assumed until a proper on-site investigation can be completed that the overhead doors possess favorable and sufficient vapor retardation qualities. The proper insulation of pipes, ducts, and other surfaces has been recognized and applied for 123 Alpha Drive. Exhaust duct within feet of an exterior was is to be line with fiberglass ductwrap, while supply and return air ducts will primarily be insulated to avoid condensation.

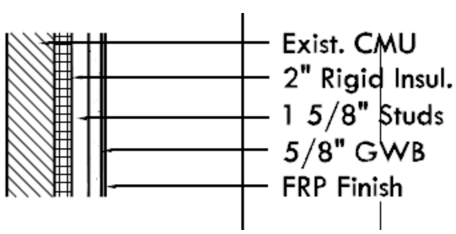

Figure 5: Typical Wall Detail 1

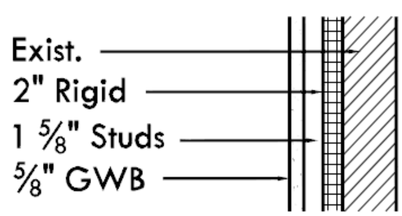

Figure 6: Typical Wall Detail 2

5.15 Building Attached Parking Garages

This section is not applicable, as the building does not feature an attached parking garage.

5.16 Air Classification and Recirculation

By referencing Table 5-2 in section 5.16 of the ASHRAE 62.1-2010 Standard, there are several areas within 123 Alpha Drive that qualify for airstreams in the Class 3 or 4 designation. These airstreams have specific rejection and recirculation requirements. The laboratory spaces are expected to have hoods which will classify the lab space as containing Class 4 air. This air must be rejected immediately and cannot be recirculated through the room or to any other room in the building. The restrooms in the building fall under Class 3 air, which allows recirculation within the space but not to any other part of the building. The office spaces and corridor are expected to contain Class 1 air, and can be recirculated to the room of origin and throughout the rest of the building.

5.17 Requirements for Buildings Containing ETS Areas

123 Alpha Drive is intended to be a smoke free building, and as long as its tenants adhere to this policy, no application to this section of the code is required.

Section 6: Ventilation Rate Procedure Analysis

Rooftop units 1 through 6 were analyzed to estimate the minimum outside air requirements for all applicable spaces. The warehouse air handling units did not contain enough information in the drawing set provided in order to produce an accurate minimum outside air requirement for their respective spaces. The air handling units supply warehouse spaces that were not included within the scope of the renovation project during THAR Geothermal's acquisition of the building.

Equation 6-1 in Section 6.2.2.1 of ASHRAE Standard 62.1 was utilized in order to calculate the breathing zone outdoor airflow value (V_{bz}).

$$Vbz = (Rp \times Pz) + (Ra \times Az)$$

For which: Az = zone floor area: the net occupiable floor area of the ventilation zone in ft2
Pz = zone population: the number of people in the ventilation zone during typical usage. (determined by counting seats from furniture plans)
Rp = outdoor airflow rate required per person as determined from Table 6-1
Ra = outdoor airflow rate required per unit area as determined from Table 6-1

The outdoor air that must be provided to ventilate the zone in question is known as the zone outdoor airflow (Voz).

$$Voz = Vbz/Ez$$

Ez = zone distribution effectiveness, which can be determined via table 6-2. Ez varies from values of 0.8,1, and 1.2 depending on the method of air distribution into the zone.

The primary outdoor air fraction (Zpz), is the minimum percentage of ventilation air compared to the required supply air. Zpz is calculated from equation 6.5.

$$Zpz = Voz/Vpz$$

Vpz is the zone primary airflow.

Table 1 (found on page 11), below, has been constructed as a summary of all six rooftop units that were chosen to be analyzed under this method. The minimum outside air and design airflow (CFM) were obtained from the project documentation. These values were compared to the outside air CFM calculation based on the formulas provided from Section 6 of ASHRAE 62.1. In an depth, detailed calculation analysis can be viewed in Appendix A at the end of this report.

Table 1: Minimum Ventilation Rates

Minimum Ventilation Rates				
Unit	Design CFM	Minimum OA CFM	ASHRAE 62.1 Min. OA CFM	Compliant?
ETR RTU-1	1600	1200	592	Yes
ETR RTU-2	3000	600	510	Yes
ETR RTU-3	3000	600	414	Yes
ETR RTU-4	3000	770	420	Yes
RTU-5	2000	600	495	Yes
RTU-6	1800	680	463.17	Yes

ASHRAE 62.1-2010 Summary

Upon analyzing the ventilation system that exists within 123 Alpha Drive, it can be concluded that all spaces have met the minimum ventilation requirements listed under the ASHRAE Standard 62.1-2010. Six rooftop units, ten air handling units, and ten exhaust fans were calculated and confirmed to meet the minimum ventilation requirements. Section 5 of ASHRAE 62.1, which specifies materials, HVAC control systems, and building enclosure specifications, has been included in this analysis. The only area of concern existing in this report was that of the contribution to the building enclosure by the numerous overhead doors on the exterior wall system of the building. These doors will be investigated in the future in order to determine whether they negatively affect moisture protection and serve as a detriment to the building envelope.

ASHRAE Standard 90.1-2010 Analysis

Section 5: Building Envelope

5.1.4 Climate

123 Alpha Drive is located in Pittsburgh, Pennsylvania. Pittsburgh's climate zone is 5A, which can be visually identified in Figure 7 below. The building envelope requirements can be found in Table B-1 of Appendix B of ASHRAE 90.1.

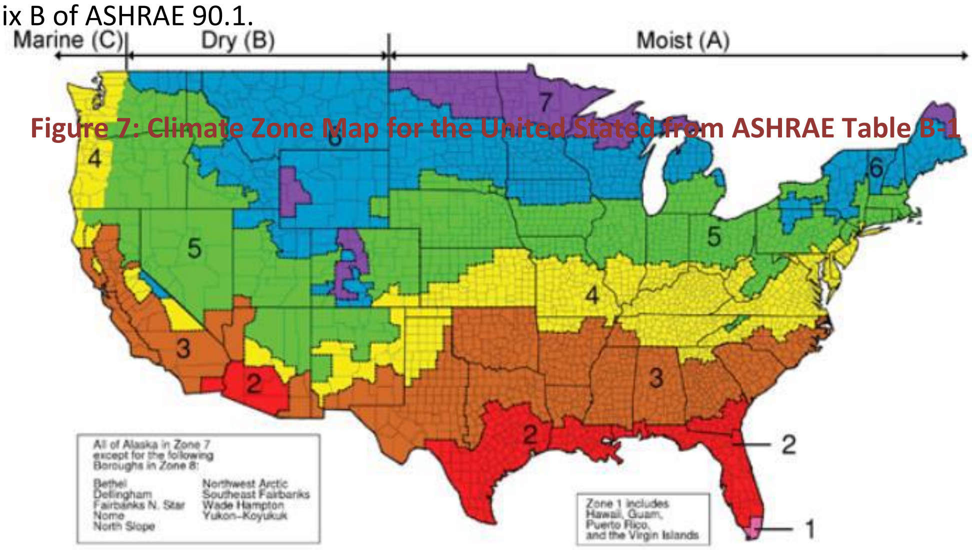

Figure 7: Climate Zone Map for the United Stated from ASHRAE Table B-1

5.4 Mandatory Provisions

The insulation required for the building envelope is to be determined in Section 5.5., 5.6 and 5.8.1 of ASHRAE 90.1. Fenestration performance will be examined in section 5.8.2 as well. A continuous air barrier must be ensured around the entire building enclosure, and 123 Alpha Drive has been confirmed to uphold that requirement. The windows and doors, save for the overhead warehouse doors, have been confirmed to be specified as sealed. Additional water-proofing has been proposed for the newly renovated areas of the building. Figure 8, below, shows the typical coping scheme for the roof deck to wall.

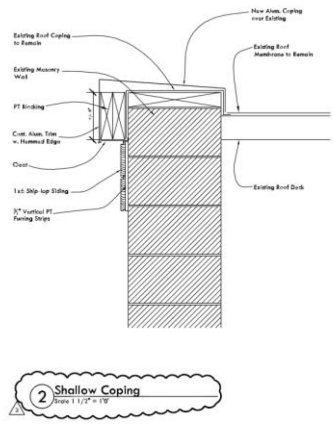

Figure 8: Typical Roof Coping Detail

5.5 Prescriptive Building Envelope

The building envelope requirements of ASHRAE Standard 90.1 can be determined to be compliant by using the prescriptive building method described in Section 5.5. The insulation values for the building envelope of the building must be compared with the requirements of the specific zone in which the building is located. Table 3 indicates the compliance determination for the walls, roof, and glazing sections of the enclosure. The building was found to be compliant with Standard 90.1, as the R-value and U-values were found to meet the minimum requirements. Vertical fenestration areas along the walls of the building are expected to be 40% of the gross wall area. From Table 2, it is confirmed that 123 Alpha Drive is compliant with this requirement.

Vertical Fenestration Area				
Face	Glazing Area (sq. ft.)	Wall Area (sq. ft.)	Glazing %	Compliant?
North	462.6	7689	6.02%	Yes
South	581.1	6585	8.82%	Yes
East	554.53	2970.7	18.67%	Yes
West	508.8	6423.9	7.92%	Yes
Total	2107.03	23668.6	8.90%	Yes

Table 2: Vertical Fenestration Area Compliance

Building Envelope For Nonresidential Zone							
Element	R-Value	Insulation Min. R-Value	U-Value	Max U-Value	SHGC	Max SHGC	Compliant?
Walls, Above Grade Mass	15.4	11.4	0.06	0.09	N/A	N/A	Yes
Roofing	27.8	20	0.04	0.048	N/A	N/A	Yes
Glazing, Nonmetal Framing	N/A	N/A	0.26	0.35	0.32	0.4	Yes
Glazing, Metal Framing	N/A	N/A	0.34	0.8	0.32	0.4	Yes

Table 3: Building Material R-Values and U-Values

Section 6: Heating, Ventilating, and Air Conditioning

6.2 Compliance Paths

The two methods that can be used to evaluate equipment efficiency can be found ASHRAE Standard 90.1. These two methods are known as the simplified approach option for HVAC systems and the mandatory provisions with prescriptive path method. 123 Alpha Drive meets the height requirement of less than two stories, but does not meet the area requirement of less than 25,000 square feet. Both requirements must be met in order to implement the simplified approach, and thus the mandatory provisions method must be used. Equipment efficiency will be evaluated under this approach.

6.3 Simplified Approach Option for HVAC Systems

This section does not apply to 123 Alpha Drive as per the aforementioned violations in Section 6.2.

6.4 Mandatory Provisions

The specifications within Section 6.4 indicate that the requirements for ASHRAE 90.1 must be explicitly stated by a manufacturer's label on all mechanical equipment. This ensures that the equipment meets the guidelines expressed in ASHRAE 90.1, and as a consequence, the efficiencies of all mechanical equipment must be in compliance with Section 6.4.

The damper leakage associated with Climate Zone 5a for a less than 3 story building is designated to be a maximum of 4 cfm for sq. ft. for motorized ventilation air intake and exhaust relief. Non-motorized ventilation air intake is not allowed for this building.

For the radiant floor cooling and heating systems within the building, the bottom surfaces of the floor structures incorporating the radiant systems will be insulated with a minimum R-35. Adjacent envelope insulation does count towards this requirement.

All outdoor air intake and exhaust systems will be equipped with motorized dampers that will shut when the spaces and/or systems are not in use. A capability for automatic shutdown during building warm-up, cool-down, and setback for should exist before occupancy begins.

Zone isolation guidelines expressed in Section 6.4.3.3.4 are to be followed and implemented into the building design.

6.5 Prescriptive Path

Each air handling unit (AHU) is equipped with a mixed air economizer that can modulate outdoor air and return air dampers to provide 100% of the desire design supply air as outdoor as for cooling. For the cooling season, the leaving air temperature is designed to be maintained at a 55 degree leaving dry bulb and a 54 degree leaving wet bulb. The leaving air temperature for the heating season is set at 150.5 degree Fahrenheit. A carbon dioxide, preconditioning coil is in place before the gas heated coil in order to produce a leaving dry bulb temperature of 45 degrees from the preconditioning coil.

6.7 Submittals

Upon completion of the project, each contractor must submit normal cut sheets and shop drawings of all equipment. This requirement includes wire diagrams, control drawings, dimensions, and an operations & maintenance manual. The authorities having jurisdiction must approve all submittals before submission to the architect.

Section 7: Service Water Heating

Pittsburgh’s Local Gas Company provides a certain water pressure for the various mechanical equipment within the building. Gas heated boilers that are greater than 4000 (BTU/hr)/gallon are mandated to have a minimum efficient of 78%. The piping in the building is properly insulated, as per the requirements of Section 7 of ASHRAE 90.1. The hot water system is run under an automation control that is currently unknown at the writing of this report. An investigation will be conducted in order to discover the correct system of operation.

Section 8: Power

123 Alpha is compliant with the National Electric Code (NEC) for construction. Under this code, feeder conductors are to be sized for a maximum voltage drop of 2% at design load, while branch circuits must be sized at a maximum voltage drop of 3%. The required drawings for power require a single-line diagram of the building’s electrical distribution system, along with floor plans indicating location and area served for all distribution in the building.

Section 9: Lighting

9.2 Compliance Method

There are no restrictions to using either the Building Area Method or the Space-by-Space Method for evaluating lighting and equipment components and properties. The simplified building area method will be used, as it is relatively trivial, but also produces a quantifiable and accepted result for the calculation of interior lighting allowances for power.

9.4 Mandatory Provisions

The building utilizes a numerous amount of occupancy sensors throughout the office and corridor spaces in an attempt to reduce the amount of energy consumption. All restrooms, offices, corridors, and conference rooms have occupancy sensors installed. The building management system or manual adjustment of lighting is needed for the rest of the building spaces. Building power density must be measured and must comply with Standard 90.1. The calculation can be completed by using the Building Area Method. Although there is some margin of error associated with this method, it is generally considered a sufficient baseline calculation. The Space-by-Space method is far more accurate, but time was not available to conduct such an examination. Appendix B contains the detailed calculations associated with this method.

Lighting Power Densities					
Area Type	Standard 90.1 LPD (W/sq.ft.)	Building Area (sq. ft.)	Building Watts	Building LPD (W)	Compliant?
Office	1.1	26000	29433	1.13	Yes
Warehouse (Low Bay)	1.2	50139	71258.1	1.42	Yes

Table 4: Lighting Power Densities

ASHRAE 90.1-2010 Summary

ASHRAE Standard 90.1 establishes the minimum energy efficiency requirements associated with non-residential buildings. Building envelope and system equipment were topics of general concern, and were used to declare that 123 Alpha Drive was indeed of energy efficient design.

123 Alpha Drive did comply with all applicable portions of ASHRAE Standard 90.1. The building envelope is not perfect, as the original building construction was not modernized. The building is insulated relatively well, however, and with an extremely efficient HVAC system, the losses experienced from a less than optimal building envelope are accounted for. The building did not possess a relatively high glazing percentage (8.9%), and the lighting power density was found to be sufficient due to the high use of fluorescent lighting throughout the building.

Mechanical system components such as the pre-conditioned carbon dioxide heating coils, radiant floor cooling and heating grids, and full economizers, played a crucial part in promoting an energy efficient HVAC system. A much more in depth and comprehensive energy model will be completed and analyzed in Technical Report 2.

References

ANSI/ASHRAE. (2010). Standard 62.1-2010, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE. (2010). Standard 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential Buildings. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

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Appendix A

Existing RTU-1

Room Number	Room Description	Az Floor Area SF	Pz Zone Population	Table 6.1 Zone Type	P/1000 Sq. ft. Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distrubtion effectiveness Table 6.2	Voz Corrected OA cfm	Vpz Primary Airflow to the zone	Max ZP Primary OA Air fraction
147	Dry Lab #2	621.93	5	Science Laboratory	25	15.55	10	0.18	155.48	111.95	1	267.43	500	0.53
148B	Dry Lab #2	302.88	0	Dry Storage	2	0.61	5	0.06	3.03	18.17	1	21.20	150	0.14
148C	Dry Lab #2	196.13	0	Dry Storage	2	0.39	5	0.06	1.96	11.77	1	13.73	150	0.09
143	Corridor	681.06	0	Corridor	-	0.00	-	0.06	0.00	40.86	1	40.86	200	0.20
145B	Dry Lab #1	225.81	0	Dry Storage	2	0.45	5	0.06	2.26	13.55	1	15.81	150	0.11
145C	Dry Lab #1	223.11	0	Dry Storage	2	0.45	5	0.06	2.23	13.39	1	15.62	150	0.10
145	Dry Lab #1	782.04	8	Science Laboratory	25	19.55	10	0.18	195.51	140.77	1	336.28	500	0.67
153	Conference Room	232.9	6	Conference	50	11.65	5	0.06	58.23	13.97	1	72.20	250	0.29
152	Changing Room	166.02	2	Break Room	50	8.30	5	0.12	41.51	19.92	1	61.43	150	0.41
155	Changing Room	208.9	2	Break Room	50	10.45	5	0.12	52.23	25.07	1	77.29	150	0.52
146	Quality Control	133.45	2	Office Space	5	0.67	5	0.06	3.34	8.01	1	11.34	150	0.08
Totals		3774.23	25						515.76	417.43		933.19	2500	0.37

Existing RTU-2

Room Number	Room Description	Az Floor Area SF	Pz Zone Population	Table 6.1 Zone Type	P/1000 Sq. ft. Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distrubtion effectiveness Table 6.2	Voz Corrected OA cfm	Vpz Primary Airflow to the zone	Max ZP Primary OA Air fraction
103	Toilet Room	621.93	0	Restroom	-	0.00	10	0.35	0.00	217.68	1	217.68	500	0.44
105	Office	302.88	0	Dry Storage	2	0.61	5	0.06	3.03	18.17	1	21.20	150	0.14
106	Office	149	1	Office Space	5	0.75	5	0.06	3.73	8.94	1	12.67	150	0.08
107	Office	149	1	Office Space	5	0.00	-	0.06	0.00	8.94	1	8.94	200	0.04
108	Office	149	1	Office Space	5	0.75	5	0.06	3.73	8.94	1	12.67	150	0.08
109	Office	149	1	Office Space	5	0.75	5	0.06	3.73	8.94	1	12.67	150	0.08
110	Office	149	1	Office Space	5	0.75	10	0.06	7.45	8.94	1	16.39	500	0.03
111	Office	149	1	Office Space	5	0.75	5	0.06	3.73	8.94	1	12.67	250	0.05
112	Office	149	1	Office Space	5	0.75	5	0.06	3.73	8.94	1	12.67	150	0.08
113	Office	149	1	Office Space	5	0.75	5	0.06	3.73	8.94	1	12.67	150	0.08
114	Office	140	1	Office Space	5	0.70	5	0.06	3.50	8.40	1	11.90	150	0.08
104	Corridor	721.33	0	Corridor	-	0	-	0.06	0	43.28	1	43.28	450	0.10
132	Women's room	225	0	Restroom	0	0	0	0.35	0	78.75	1	78.75	180	0.44
133	Men's Room	225	0	Restroom	0	0	0	0.35	0	78.75	1	78.75	180	0.44
Totals		3428.14	9						36.33	516.55		552.88	3310	0.17

Existing RTU-3

Room Number	Room Description	Az Floor Area SF	Pz Zone Population	Table 6.1 Zone Type	P/1000 Sq. ft. Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distrubtion effectiveness Table 6.2	Voz Corrected OA cfm	Vpz Primary Airflow to the zone	Max ZP Primary OA Air fraction
100	Reception	425.49	4	Reception	30	12.76	5	0.35	63.82	148.92	1	212.75	395	0.54
101A	Open Work Area	1176.95	20	Office Space	5	5.88	5	0.06	29.42	70.62	1	100.04	1185	0.08
102	Office	525	5	Office Space	5	2.63	5	0.06	13.13	31.50	1	44.63	580	0.08
101B	Open Work Area	673.01	9	Office Space	5	3.37	5	0.06	16.83	40.38	1	57.21	790	0.07
Totals		2800.45	38						123.20	291.42		414.62	2950	0.14

Existing RTU-4

Room Number	Room Description	Az Floor Area SF	Pz Zone Population	Table 6.1 Zone Type	P/1000 Sq. ft. Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distrubtion effectiveness Table 6.2	Voz Corrected OA cfm	Vpz Primary Airflow to the zone	Max ZP Primary OA Air fraction
117	Conference Rooms	448	10	Conference	50	22.40	5	0.35	112.00	156.80	1	268.80	630	0.43
118	Office	187	1	Office Space	5	0.94	5	0.06	4.68	11.22	1	15.90	150	0.11
119	Office	187	1	Office Space	5	0.94	5	0.06	4.68	11.22	1	15.90	150	0.11
120	Office	187	1	Office Space	5	0.94	5	0.06	4.68	11.22	1	15.90	150	0.11
121	Office	187	1	Office Space	5	0.94	5	0.06	4.68	11.22	1	15.90	150	0.11
129	Office	187	1	Office Space	5	0.94	5	0.06	4.68	11.22	1	15.90	150	0.11
Open	Open Work Area	968	21	Office Space	5	4.84	5	0.06	24.20	58.08	1	82.28	1680	0.05
Totals		2351	36						159.58	270.98		430.56	3060	0.14

Existing RTU-5

Room Number	Room Description	Az Floor Area SF	Pz Zone Population	Table 6.1 Zone Type	P/1000 Sq. ft. Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distrubtion effectiveness Table 6.2	Voz Corrected OA cfm	Vpz Primary Airflow to the zone	Max ZP Primary OA Air fraction
122	Café	1337.9	15	Conference	100	133.79	7.5	0.18	112.50	240.82	1	353.32	1180	0.30
124	Storage	208	1	Storage	2	0.42	5	0.06	5.00	12.48	1	17.48	200	0.09
125	Men's Room	85	0	Office Space	0	0.00	0	0.35	0.00	29.75	1	29.75	150	0.20
126	Women's Room	85	0	Office Space	0	0.00	0	0.35	0.00	29.75	1	29.75	150	0.20
127	Conference Room	105.4	4	Office Space	50	5.27	5	0.06	20.00	6.32	1	26.32	180	0.15
128	Conference Room	144.9	6	Office Space	50	7.25	5	0.06	30.00	8.69	1	38.69	200	0.19
Totals		1966.2	26						167.50	327.82		495.32	2060	0.24

Existing RTU-6

Room Number	Room Description	Az Floor Area SF	Pz Zone Population	Table 6.1 Zone Type	P/1000 Sq. ft. Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distrubtion effectiveness Table 6.2	Voz Corrected OA cfm	Vpz Primary Airflow to the zone	Max ZP Primary OA Air fraction
135	Women's Room	303.92	0	Restroom	0	0.00	0	0.35	0.00	106.37	1	106.37	180	0.59
136	Men's Room	290.29	0	Restroom	0	0.00	0	0.35	0.00	101.60	1	101.60	180	0.56
141	Storage	290.29	1	Storage	2	0.58	5	0.06	0.00	17.42	1	17.42	150	0.12
144	Break Room	308.25	10	Break Room	50	15.41	5	0.12	0.00	36.99	1	36.99	260	0.14
139	Break Room	247.96	8	Break Room	50	12.40	5	0.12	40.00	29.76	1	69.76	235	0.30
134	Corridor	869.04	0	Corridor	0	0.00	0	0.06	0.00	52.14	1	52.14	555	0.09
140	Break Room	282.4	9	Break Room	50	14.12	5	0.12	45.00	33.89	1	78.89	240	0.33
Totals		2592.15	28						85.00	378.17		463.17	1800	0.26

Appendix B

Lighting Fixture	Watts/Fixture	# of Fixtures	Watts Used
A	64	33	2112.00
B	34	41	1394.00
BE	34	19	646.00
C	64	111	7104.00
CE	64	9	576.00
D	32	5	160.00
DE	32	9	288.00
EX	0	1	0.00
F	18	7	126.00
G	17	1	17.00
H	32	18	576.00
HE	32	14	448.00
J	96	9	864.00
K	216	59	12744.00
L	96	2	192.00
M	42	10	420.00
N	26	8	208.00
P	3	2	6.00
Q	3	8	24.00
R	64	2	128.00
S	0	2	0.00
T	52	17	884.00
U	32	1	32.00
V	64	6	384.00
W	100	1	100.00
Total			29433.00