

Mechanical Technical Report 1

ASHRAE Standard 62.1 Ventilation Compliance Evaluation



Lutheran Theological Seminary at Philadelphia The New Learning Center

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Mechanical Option

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Executive Summary

The Ventilation Rate Procedure of ASHRAE Standard 62.1, 2004 version, is used to confirm that proper outdoor air is brought in to each space for occupants. The calculations have been done to analyze the performance and code verification of the Luther Theological Seminary at Philadelphia, The New Learning Center. The outdoor air requirement for each zone has been calculated and totaled up through the fan coils, all the way back to the Rooftop Air Handling Units.

The New Learning Center has a relatively complicated HVAC system. There are 3 primary RTU's with 100% outdoor air, an energy recovery heat wheel, hot gas heat, direct expansion cooling, and gas reheat. There is also a outdoor air plenum in the basement to supply the fresh air to the basement and the first floor breezeway. The outdoor air is then blown into a mechanical closet with fan coils. In the closet, the air is mixed with return air and then ducted to the rooms.

The HVAC system must serve all 60,000 square feet of The New Learning Center. The building must meet all local and national codes, including ASHRAE 62.1. The system serves a variety of rooms. These rooms include mechanical rooms, a kitchen, storage spaces, classrooms, meeting rooms, assembly areas, offices, and lounges

The outdoor air was calculated for each individual room based on many factors. Occupancy, square footage, use, and outside air percentage combined to make a total for each outdoor air intake. The conclusions are presented in Table 1.

| | Calculated Minimum OA (CFM) | Design OA (CFM) | ASHRAE 62.1 Code Verification |
|-----------------|--------------------------------|--------------------|----------------------------------|
| RTU-1 | 5995 | 6225 | Verified |
| RTU-2 | 3105 | 6125 | Verified |
| RTU-3 | 1528 | 1685 | Verified |
| Basement Plenum | 1711 | 2600 | Verified |

Table 1 shows that the minimum outdoor air requirement is met by all of the units in the system. These calculations are based off of the drawings and schedules provided by Paul H. Yeomans, Inc. RTU-2 may be oversized for a few reasons. One reason is that the occupancy and function can be interpreted in many different ways by ASHRAE Standard 62.1. Another reason is that the system supplies 100% outdoor air to the fan coils, and the air flow volume could be driven by the cooling load.

A third thing that may drive the supply is that RTU-2 serves many exterior rooms and it would be beneficial to supply more air in those rooms to keep the temperature constant and well mixed.

Mechanical System Summary

The mechanical system for The New Learning Center is designed as a dedicated outdoor air system. The system is controlled by DDC controls and is all tied back into the main controller. The system has three packaged DX rooftop units with 100% outside air. These units have integral heat recovery through a heat wheel, gas heat, direct expansion cooling, and hot gas reheat. RTU-1 and RTU-2 have 270 MBH of heating capacity and 320 MBH of cooling capacity. The smaller unit, RTU-3, has 90 MBH heating and 100 MBH of cooling capacity. These air handlers feed fan coil units in mechanical closets. The air is mixed within the closet, reconditioned, and then supplied to the rooms. The fan coils are various sizes, all based upon the room or group of rooms that they supply air to. In cooling mode the water is delivered to the coil at 45 F and leave at 55F. When heat is needed the water arrives at the coil at 180 F and leaves at 160 F. All of the fan coils are equipped with a two pipe system for heating and cooling coils.

The hot water system consists of two gas fired boilers in the basement mechanical room. Each of these boilers is designed for 1250 MBH. This hot water is run through variable speed pumps to fan coil units and constant volume pumps to the fin tube radiation.

The chilled water system is fueled by the air cooled chiller on the roof. The chiller is made for low ambient conditions so it is capable for operation during the colder months to cool rooms with high cooling loads. It also has variable speed for low load conditions. The chiller is sized for 150 tons. The water arrives at the chiller evaporator at 42 F and leaves at 56 F.

Assumptions

- The effectiveness, E_z , for the supply air of all spaces within the building is 1.
- The building is consistent with the drawings and schedules.
- There is no air mixing in the RTU's when it travels through the energy recovery wheel.
- Perfect air mixing occurs in the fan coil mechanical closet when outdoor air is combined with the return air.
- Outdoor air is supplied correctly to the fan coils when more than one shares a mechanical closet.
- Breathing zone outdoor air will be calculated in accordance to ASHRAE Standard 62.1.
- Occupancy will either be estimated with number of seats, furniture, or in accordance to ASHRAE 62.1 based on estimated occupancy per 1000 square feet.
- Console fan coil units will have the outdoor air intake designated on the schedule.
- Outdoor air is of good quality.

Comparison of Outdoor Air Procedures

ASHRAE Standard 62.1 explains two different methods to analyze ventilation of spaces and a building. The two methods are Indoor Air Quality (IAQ) and the Ventilation Rate Procedure (VRP).

The Ventilation Rate Procedure is based around tables and equations in ASHRAE 62.1. Four main things are taken into account to perform these equations. The main points are function, occupancy, square footage, and outdoor air fraction. With the knowledge of these four points, you can pull the rest of the information from tables and plug it into the necessary equations. When calculated back to the AHU you can decide whether or not the spaces and building is properly ventilated.

The Indoor Air Quality approach attacks the ventilation issue by looking at contaminants in spaces. The three main parts of the analysis are contaminant sources, contaminant concentration levels, and acceptability targets provided in ASHRAE. At times this procedure may reduce the necessary ventilation air to a space. This can be done by cleaning air, whether is be by filtering or other air purification methods.

The VRP is the procedure that is used most extensively throughout the profession. This procedure is more simplified, can be calculated more easily, and is more conservative most of the time. The IAQ procedure would include research such as air purification levels, contamination levels of individuals and other sources, and building materials. Therefore, these spaces will be evaluated with the Ventilation Rate Procedure.

Procedure**Step 1:**

Determine the area and occupancy of each room. If a room layout is not available to give a good assumption for occupancy, use the data in ASHRAE for estimation.

Step 2:

Calculate the breathing zone required outdoor airflow.

$$V_{bz} = R_p * P_z + R_a * A_z$$

R_p = Outdoor air required per person (ASHRAE Table 6-1)

P_z = Occupancy of the zone

R_a = Outdoor air per square foot (ASHRAE Table 6-1)

A_z = Area of the zone

Step 3:

Determine the Zone Air Distribution Effectiveness, E_z . These values can be determined by ASHRAE Table 6-2. In this case all of the zones have an effectiveness of 1.

Step 4:

Determine the Zone Outdoor Airflow.

$$V_{oz} = V_{bz} / E_z$$

In this case $V_{oz} = V_{bz}$ in all spaces.

Step 5:

Determine the outdoor air fraction, Z_p .

$$Z_p = V_{oz} / V_{pz}$$

V_{pz} = Zone primary airflow

Step 6:

Determine the System Ventilation Efficiency, E_v . For values of Z_p less than or equal to .55, use Table 6-3. If the value of Z_p is greater than .55, refer to Appendix A for necessary calculations.

Step 7:

Determine the Occupant Diversity Factor.

$$D = P_s / (\sum P_z)$$

P_s = System Population

Step 8:

Total the Uncorrected Outdoor Air for the system.

$$V_{ou} = D \cdot \sum R_p \cdot P_z + \sum R_a \cdot A_z$$

Step 9:

Determine the Design Outdoor Air Intake Flow, V_{ot} .

$$V_{ot} = V_{ou} / E_v$$

Step 10:

At the conclusion of the outdoor air requirement calculations, they can be compared to the design outdoor air supply. Through the comparison, the supply air can be verified that it meets code.

Analysis and Conclusions

The analysis of The New Learning Center slightly differs from a more conventional building because of where the mixing occurs in the system. Since the air mixing occurs in the mechanical closets where the fan coils reside, the closets themselves must be analyzed as their or single or multi zone systems. After that is finished, the fan coils can then be traced back to the AHU that serve them. The outdoor air requirement for these AHU's can be determined by the summation of the requirements for their designated fan coil zones.

Upon completion of the calculations, the requirements for the outdoor air delivered by the AHU's are compared to the design conditions. In this case, all of the units supply enough fresh air to meet and exceed code. All three Rooftop Units as well as the basement outdoor air plenum are sized properly. Therefore, the building as a whole has enough outdoor air supplied to properly operate and occupy The New Learning Center. This comparison is shown in brief in Table 1.

| | Calculated Minimum OA (CFM) | Design OA (CFM) | ASHRAE 62.1 Code Verification |
|-----------------|--------------------------------|--------------------|----------------------------------|
| RTU-1 | 5995 | 6225 | Verified |
| RTU-2 | 3105 | 6125 | Verified |
| RTU-3 | 1528 | 1685 | Verified |
| Basement Plenum | 1711 | 2600 | Verified |

The analysis in this building is not only done for the AHU's, but also for each individual closet. These closets can be made up of anywhere from one to three fan coil units. There are 26 such mechanical closets in The New Learning Center. There are also 20 such zones that are served by console fan coil units only, all which comply. Of the 26 mechanical closet systems, only 5 do not meet code as the spaces were analyzed with ASHRAE and the assumptions made in this analysis. This does not make the design insufficient, it merely means that different assumptions, decisions, or functions were used in calculation. ASHRAE 62.1 has a chance to leave open the ability to assume various functions of the room depending on the owner's decisions, engineer's previous knowledge of occupancies, and a few other variations.

Two of the closets that were slightly short were in the basement, although the basement as a whole has enough outdoor air supplied. These zones may be short assuming that some of the extra

outdoor air will be supplied to the corridor and transferred into the storage areas before being returned. This is not a very critical area since the occupancy of the entire basement is zero.

Two more of the closets that were slightly short of the calculated required outdoor air serve the large lecture space on the first floor. This is a situation that can be treated in several different ways. The large room has folding partitions that can split the room up into three smaller classrooms. If the occupancy and airflow is treated as three separate classrooms, the closets will have plenty of outdoor air. If the calculations are done as one large assembly area, they will be slightly short of the required outdoor air volume.

The final closet that is just shy of the calculated airflow serves a distance learning classroom on the third floor. As with the other space, if the airflow and occupancy is based as a regular classroom, the outdoor air is sufficient. However, if the room is calculated as if it is a lecture classroom, it comes up about 10% short.

Although there are a few discrepancies between the required outdoor air flow showed and the design, it does not mean there were any mistakes during design. With the proper assumptions and owner input, all of these calculations would be sufficient to supply all zones. The evaluation and verification of the Air Handling Units also suggests that the zones were calculated and designed properly. This building would absolutely exceed any code analysis.

Appendix A

Plenum

Calculated CFM = 1710.6

Designed CFM = 2600

FCU B-1

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-----------------|-------|----------|------|---------------|-------------------------|----|-------|-------|-----|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Compact Storage | B04 | Storage | 2932 | 0 | 0.12 | 0 | 352 | 0 | 352 | 1215 | 0.29 | | | | | | |
| Total | | | | | | | | | | | | 352 | 1215 | 0.29 | 0.8 | 439.8 | 300 |

FCU B-2, 3

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-----------------|-------|----------|------|---------------|-------------------------|----|-------|-------|------|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Corridor | B07 | Corridor | 2082 | 0 | 0.06 | 0 | 125 | 0 | 125 | 1080 | 0.12 | | | | | | |
| Archives Region | B08 | Storage | 3549 | 0 | 0.12 | 0 | 426 | 0 | 426 | 1560 | 0.27 | | | | | | |
| Archives Region | B09 | Storage | 332 | 0 | 0.12 | 0 | 39.8 | 0 | 39.8 | 280 | 0.14 | | | | | | |
| Archives Region | B11 | Storage | 674 | 0 | 0.12 | 0 | 80.9 | 0 | 80.9 | 200 | 0.40 | | | | | | |
| Total | | | | | | | | | | | | 672 | 3120 | 0.4 | 0.7 | 959.3 | 710 |

FCU B-4, 5

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------------|-------|----------|-----|---------------|-------------------------|----|-------|-------|-----|------|------|-----|------|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Breezeway | 117 | Lobbies | 848 | 20 | 0.06 | 5 | 50.9 | 100 | 151 | 3500 | 0.04 | | | | | | |
| Total | | | | | | | | | | | | 151 | 3500 | 0.04 | 1 | 150.9 | 240 |

SF-1

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-----------------|-------|----------|------|---------------|-------------------------|----|-------|-------|-----|------|------|-----|------|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Mechanical Room | B05 | Storage | 1338 | 0 | 0.12 | 0 | 161 | 0 | 161 | 1350 | 1.00 | | | | | | |
| Total | | | | | | | | | | | | 161 | 1350 | 1 | 1 | 160.6 | 1350 |

RTU-1

Calculated CFM = 5993.3

Designed CFM = 6225

FCU 1-1, 2

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|------------------------|-------|---------------|------|---------------|-------------------------|-----|-------|-------|------|------|------|-----|------|---------|-----|--------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Reception Hall / Class | 101 | Lecture Class | 1288 | 83 | 0.06 | 7.5 | 77.3 | 623 | 700 | 1900 | 0.37 | | | | | | |
| A/V Control | 103A | Office | 65 | 1 | 0.06 | 5 | 3.9 | 5 | 8.9 | 220 | 0.04 | | | | | | |
| Corridor | 103H | Corridor | 1060 | 5 | 0.06 | 5 | 63.6 | 25 | 88.6 | 1520 | 0.06 | | | | | | |
| Total | | | | | | | | | | | | 797 | 3425 | 0.4 | 0.7 | 1139.0 | 1040 |

FCU 1-3, 4

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|------------------------|-------|---------------|------|---------------|-------------------------|-----|-------|-------|------|------|------|------|------|---------|-----|------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Reception Hall / Class | 101 | Lecture Class | 2577 | 167 | 0.06 | 7.5 | 155 | 1253 | 1407 | 3130 | 0.45 | | | | | | |
| Total | | | | | | | | | | | | 1407 | 3130 | 0.45 | 0.7 | #### | 1960 |

FCU 2-1

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------------|-------|---------------|------|---------------|-------------------------|-----|-------|-------|-----|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Classroom | 201 | Lecture Class | 1525 | 70 | 0.06 | 7.5 | 91.5 | 525 | 617 | 1575 | 0.39 | | | | | | |
| Total | | | | | | | | | | | | 617 | 1575 | 0.39 | 0.7 | 880.7 | 975 |

FCU 2-2, 3

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-------------------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|-----|-----|------|-----|-----|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Seminar / Conference | 202 | Conference | 390 | 16 | 0.06 | 5 | 23.4 | 80 | 103 | 960 | 0.11 | | | | | | |
| Total | | | | | | | | | | | | 103 | 960 | 0.11 | 1 | 103.4 | 280 |

FCU 2-4, 5

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| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-------------------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|-----|-----|------|-----|-----|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Seminar / Conference | 203 | Conference | 378 | 16 | 0.06 | 5 | 22.7 | 80 | 103 | 960 | 0.11 | | | | | | |
| Total | | | | | | | | | | | | 103 | 960 | 0.11 | 1 | 102.7 | 280 |

FCU 2-8, 9

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|-----|-----|------|-----|-----|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Faculty Conference | 208 | Conference | 379 | 16 | 0.06 | 5 | 22.7 | 80 | 103 | 890 | 0.12 | | | | | | |
| Total | | | | | | | | | | | | 103 | 890 | 0.12 | 1 | 102.7 | 280 |

FCU 3-1

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|----------------------------|-------|---------------|------|---------------|-------------------------|-----|-------|-------|-----|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Distance Learning Class | 301 | Lecture Class | 1505 | 53 | 0.06 | 7.5 | 90.3 | 398 | 488 | 1465 | 0.33 | | | | | | |
| Total | | | | | | | | | | | | 488 | 1465 | 0.42 | 0.7 | 696.9 | 660 |

FCU 3-2, 3

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-------------------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|-----|------|------|-----|------|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Seminar / Conference | 302 | Conference | 362 | 16 | 0.06 | 5 | 21.7 | 80 | 102 | 1220 | 0.08 | | | | | | |
| Total | | | | | | | | | | | | 102 | 1220 | 0.08 | 1 | 101.7 | 280 |

FCU 3-4, 5

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-------------------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|-----|------|------|-----|-----|---------|----|-----|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Seminar / Conference | 303 | Conference | 378 | 16 | 0.06 | 5 | 22.7 | 80 | 103 | 1360 | 0.08 | | | | | | |

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|-------|--|--|--|--|--|--|--|--|--|--|--|-----|------|------|---|-------|-----|
| Total | | | | | | | | | | | | 103 | 1360 | 0.08 | 1 | 102.7 | 280 |
|-------|--|--|--|--|--|--|--|--|--|--|--|-----|------|------|---|-------|-----|

FCU 3-6, 7

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-----------|-------|---------------|------|---------------|-------------------------|-----|-------|-------|------|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Corridor | 305 | Corridor | 1372 | 3 | 0.06 | 5 | 82.3 | 15 | 97.3 | 1440 | 0.07 | | | | | | |
| Classroom | 306 | Lecture Class | 855 | 37 | 0.06 | 7.5 | 51.3 | 278 | 329 | 720 | 0.46 | | | | | | |
| Alcove | 314 | Storage | 114 | 0 | 0.12 | 0 | 13.7 | 0 | 13.7 | 60 | 0.23 | | | | | | |
| Copy Room | 317 | Storage | 102 | 0 | 0.12 | 0 | 12.2 | 0 | 12.2 | 75 | 0.16 | | | | | | |
| Total | | | | | | | | | | | | 452 | 2300 | 0.46 | 0.6 | 753.4 | 1030 |

RTU-2

Calculated CFM = 3104.9

Designed CFM = 6125

FCU 1-5, 6

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------|-------|----------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Lounge | 102 | Office | 953 | 20 | 0.06 | 5 | 57.2 | 100 | 157 | 930 | 0.17 | | | | | | |
| Pantry | 102A | Storage | 151 | 0 | 0.12 | 0 | 18.1 | 0 | 18.1 | 90 | 0.20 | | | | | | |
| Lounge | 102C | Office | 745 | 15 | 0.06 | 5 | 44.7 | 75 | 120 | 730 | 0.16 | | | | | | |
| Coat | 102F | Storage | 111 | 0 | 0.12 | 0 | 13.3 | 0 | 13.3 | 70 | 0.19 | | | | | | |
| Total | | | | | | | | | | | | 308 | 1820 | 0.2 | 0.9 | 342.6 | 630 |

FCU 1-7, 8, 9

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|---------------------------------------|-------|----------|------|---------------|-------------------------|-----|-------|-------|------|------|------|-----|-----|---------|----|-----|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Corridor | 103 | Corridor | 1060 | 4 | 0.06 | 5 | 63.6 | 20 | 83.6 | 1120 | 0.07 | | | | | | |
| A/V Control | 103D | Office | 65 | 1 | 0.06 | 5 | 3.9 | 5 | 8.9 | 220 | 0.04 | | | | | | |
| Corridor | 106 | Corridor | 381 | 0 | 0.06 | 0 | 22.9 | 0 | 22.9 | 360 | 0.06 | | | | | | |
| Corridor | 106A | Corridor | 160 | 0 | 0.06 | 0 | 9.6 | 0 | 9.6 | 165 | 0.06 | | | | | | |
| Kitchen | 107 | Café | 353 | 2 | 0.18 | 7.5 | 63.5 | 15 | 78.5 | 280 | 0.28 | | | | | | |
| Kitchen | 107B | Café | 379 | 1 | 0.18 | 7.5 | 68.2 | 7.5 | 75.7 | 140 | 0.54 | | | | | | |
| Storage Security / Receptionist | 109 | Storage | 743 | 0 | 0.12 | 0 | 89.2 | 0 | 89.2 | 420 | 0.21 | | | | | | |
| | 110 | Lobbies | 1310 | 10 | 0.06 | 5 | 78.6 | 50 | 129 | 1425 | 0.09 | | | | | | |

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The New Learning Center

| | | | | | | | | | | | | | | | | | | |
|----------------|------|----------|-----|---|------|---|------|---|------|-----|------|-----|------|------|-----|-------|--|------|
| Lockers | 111 | Corridor | 252 | 1 | 0.06 | 5 | 15.1 | 5 | 20.1 | 75 | 0.27 | | | | | | | |
| Mailroom | 111A | Office | 504 | 0 | 0.06 | 5 | 30.2 | 0 | 30.2 | 80 | 0.38 | | | | | | | |
| Copy Room | 112 | Storage | 81 | 0 | 0.12 | 0 | 9.72 | 0 | 9.72 | 50 | 0.19 | | | | | | | |
| Mail Prep Room | 114 | Office | 333 | 1 | 0.06 | 5 | 20 | 5 | 25 | 110 | 0.23 | | | | | | | |
| Total | | | | | | | | | | | | 582 | 3860 | 0.54 | 0.6 | 970.1 | | 2405 |

FCU 2-6, 7

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|------------------------|-------|----------|------|---------------|-------------------------|----|-------|-------|------|-----|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Corridor | 205 | Corridor | 1150 | 3 | 0.06 | 5 | 69 | 15 | 84 | 690 | 0.12 | | | | | | |
| Faculty / Staff Lounge | 206 | Office | 545 | 15 | 0.06 | 5 | 32.7 | 75 | 108 | 540 | 0.20 | | | | | | |
| Corridor | 207 | Corridor | 685 | 0 | 0.06 | 0 | 41.1 | 0 | 41.1 | 280 | 0.15 | | | | | | |
| Copy Room | 210 | Storage | 84 | 0 | 0.12 | 0 | 10.1 | 0 | 10.1 | 70 | 0.14 | | | | | | |
| Alcove | 211 | Storage | 110 | 1 | 0.12 | 0 | 13.2 | 0 | 13.2 | 80 | 0.17 | | | | | | |
| Total | | | | | | | | | | | | 256 | 1660 | 0.2 | 0.9 | 284.5 | 680 |

FCU 2-10, 11

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|---------------|-------|---------------|-----|---------------|-------------------------|-----|-------|-------|------|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| UTI Classroom | 204 | Lecture Class | 855 | 34 | 0.06 | 7.5 | 51.3 | 255 | 306 | 880 | 0.35 | | | | | | |
| Classroom | 209 | Lecture Class | 947 | 41 | 0.06 | 7.5 | 56.8 | 308 | 364 | 1360 | 0.27 | | | | | | |
| Storage | 209A | Storage | 130 | 0 | 0.12 | 0 | 15.6 | 0 | 15.6 | 50 | 0.31 | | | | | | |
| Total | | | | | | | | | | | | 686 | 2290 | 0.35 | 0.8 | 857.8 | 1290 |

FCU 2-14

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-----------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|------|-----|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Storage | 216 | Sotrage | 270 | 0 | 0.12 | 0 | 32.4 | 0 | 32.4 | 125 | 0.26 | | | | | | |
| Conference Room | 217 | Conference | 278 | 10 | 0.06 | 5 | 16.7 | 50 | 66.7 | 430 | 0.16 | | | | | | |
| Total | | | | | | | | | | | | 99.1 | 555 | 0.26 | 0.8 | 123.9 | 130 |

ASHRAE Standard 62.1 Ventilation Compliance Evaluation

FCU 3-10, 11

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|----------------|-------|---------------|-----|---------------|-------------------------|-----|-------|-------|------|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Heinecken Room | 304 | Lecture Class | 869 | 30 | 0.06 | 7.5 | 52.1 | 225 | 277 | 1120 | 0.25 | | | | | | |
| Board Room | 309 | Conference | 969 | 25 | 0.06 | 5 | 58.1 | 125 | 183 | 1180 | 0.16 | | | | | | |
| Pantry | 309A | Storage | 110 | 0 | 0.12 | 0 | 13.2 | 0 | 13.2 | 60 | 0.22 | | | | | | |
| Total | | | | | | | | | | | | 473 | 2360 | 0.25 | 0.9 | 526.1 | 1005 |

RTU-3

Calculated CFM = 1528.0

Designed CFM = 1685

FCU 2-20

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|---------------------|-------|----------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Corridor | 220 | Corridor | 791 | 0 | 0.06 | 0 | 47.5 | 0 | 47.5 | 360 | 0.13 | | | | | | |
| Admission Assistant | 222 | Office | 495 | 8 | 0.06 | 5 | 29.7 | 40 | 69.7 | 370 | 0.19 | | | | | | |
| Corridor | 225 | Corridor | 315 | 0 | 0.06 | 0 | 18.9 | 0 | 18.9 | 75 | 0.25 | | | | | | |
| Work Room | 226 | Office | 228 | 1 | 0.06 | 5 | 13.7 | 5 | 18.7 | 290 | 0.06 | | | | | | |
| Coffee Area | 231 | Corridor | 85 | 1 | 0.06 | 5 | 5.1 | 5 | 10.1 | 100 | 0.10 | | | | | | |
| Total | | | | | | | | | | | | 165 | 1215 | 0.25 | 0.9 | 183.2 | 265 |

FCU 3-14

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------------|-------|----------|-----|---------------|-------------------------|----|-------|-------|-----|------|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Computer Lab | 315 | Computer | 457 | 17 | 0.12 | 10 | 54.8 | 170 | 225 | 1200 | 0.19 | | | | | | |
| Total | | | | | | | | | | | | 225 | 1200 | 0.19 | 0.9 | 249.8 | 480 |

FCU 3-15, 16

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-------------------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|-----|------|------|-----|-----|---------|----|-----|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Seminar / Conference | 316 | Conference | 374 | 16 | 0.06 | 5 | 22.4 | 80 | 102 | 1220 | 0.08 | | | | | | |

| | | | | | | | | | | | | | | | | | |
|-------|--|--|--|--|--|--|--|--|--|--|--|-----|------|------|---|-------|-----|
| Total | | | | | | | | | | | | 102 | 1220 | 0.08 | 1 | 102.4 | 280 |
|-------|--|--|--|--|--|--|--|--|--|--|--|-----|------|------|---|-------|-----|

FCU 3-18, 19

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|----------------|-------|------------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|-----|------|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Breakout Space | 319 | Conference | 318 | 12 | 0.06 | 5 | 19.1 | 60 | 79.1 | 720 | 0.11 | | | | | | |
| Breakout Space | 320 | Conference | 315 | 12 | 0.06 | 5 | 18.9 | 60 | 78.9 | 510 | 0.15 | | | | | | |
| Total | | | | | | | | | | | | 158 | 1230 | 0.15 | 1 | 158.0 | 240 |

FCU 3-21, 22

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------------|-------|-----------|------|---------------|-------------------------|----|-------|-------|------|-----|------|-----|------|---------|-----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Corridor | 312 | Corridor | 1544 | 0 | 0.06 | 0 | 92.6 | 0 | 92.6 | 885 | 0.10 | | | | | | |
| Teaching Lab | 322 | Classroom | 842 | 30 | 0.12 | 10 | 101 | 300 | 401 | 920 | 0.44 | | | | | | |
| Storage | 322C | Storage | 136 | 0 | 0.12 | 0 | 16.3 | 0 | 16.3 | 115 | 0.14 | | | | | | |
| Total | | | | | | | | | | | | 510 | 1920 | 0.44 | 0.7 | 728.6 | 780 |

FCU 3-23, 24

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-------|-------|----------|-----|---------------|-------------------------|----|-------|-------|-----|------|------|-----|------|---------|----|-------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| MMRC | 323 | Office | 434 | 16 | 0.06 | 5 | 26 | 80 | 106 | 1220 | 0.09 | | | | | | |
| Total | | | | | | | | | | | | 106 | 1220 | 0.09 | 1 | 106.0 | 280 |

CONSOLE ONLY

FCU 1-10

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|----------------------|-------|----------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|-----|-----|---------|----|-----|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Shipping / Receiving | 113 | Shipping | 449 | 0 | 0.12 | 0 | 53.9 | 0 | 53.9 | 385 | 0.14 | | | | | | |

| | | | | | | | | | | | | | | | | | | |
|-------|--|--|--|--|--|--|--|--|--|--|--|--|------|-----|------|---|------|----|
| Total | | | | | | | | | | | | | 53.9 | 385 | 0.14 | 1 | 53.9 | 70 |
|-------|--|--|--|--|--|--|--|--|--|--|--|--|------|-----|------|---|------|----|

FCU 1-11

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|------------------|-------|----------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|------|-----|---------|----|------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Custodian Office | 115 | Office | 305 | 0 | 0.06 | 5 | 18.3 | 0 | 18.3 | 235 | 0.08 | | | | | | |
| Total | | | | | | | | | | | | 18.3 | 235 | 0.1 | 1 | 18.3 | 20 |

FCU 2-12, 13, 15-19, 21-23, 25

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------|-------|----------|-----|---------------|-------------------------|----|-------|-------|-----|-----|------|-----|-----|---------|----|------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Office | 214 | Office | 184 | 1 | 0.06 | 5 | 11 | 5 | 16 | 290 | 0.06 | | | | | | |
| Total | | | | | | | | | | | | 16 | 290 | 0.06 | 1 | 16.0 | 20 |

FCU 2-24

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|---------------|-------|----------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|------|-----|---------|----|------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Financial Aid | 230 | Office | 169 | 1 | 0.06 | 5 | 10.1 | 5 | 15.1 | 245 | 0.06 | | | | | | |
| Total | | | | | | | | | | | | 15.1 | 245 | 0.06 | 1 | 15.1 | 20 |

FCU 2-26

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|------------------------|-------|----------|-----|---------------|-------------------------|----|-------|-------|------|-----|------|------|-----|---------|----|------|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| Grad Program Assistant | 233 | Office | 190 | 1 | 0.06 | 5 | 11.4 | 5 | 16.4 | 180 | 0.09 | | | | | | |
| Total | | | | | | | | | | | | 16.4 | 180 | 0.09 | 1 | 16.4 | 20 |

FCU 3-8,9

| Room | Label | Function | Az | Assumed Pz | ASHRAE 62.1- 2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|------|-------|----------|----|---------------|-------------------------|----|-------|-------|-----|-----|----|-----|-----|---------|----|-----|----------------|
| | | | | | Ra | Rp | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

ASHRAE Standard 62.1 Ventilation Compliance Evaluation

| Room | Label | Function | Az | Pz | Ra | Rp | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|--------|-------|----------|-----|----|------|----|-------|-------|------|-----|------|------|-----|---------|----|------|-------------|
| Office | 307 | Office | 199 | 1 | 0.06 | 5 | 11.9 | 5 | 16.9 | 290 | 0.06 | | | | | | |
| Total | | | | | | | | | | | | 16.9 | 290 | 0.06 | 1 | 16.9 | 20 |

FCU 3-12, 13

| Room | Label | Function | Az | Pz | ASHRAE 62.1-2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|-------------------------|-------|----------|-----|----|------------------|----|-------|-------|------|-----|------|------|-----|---------|----|------|-------------|
| | | | | | Assumed | Ra | | | | | | | | | | | |
| Server / Work / Control | 313 | Office | 364 | 1 | 0.06 | 5 | 21.8 | 5 | 26.8 | 490 | 0.05 | | | | | | |
| Total | | | | | | | | | | | | 26.8 | 490 | 0.05 | 1 | 26.8 | 40 |

FCU 3-17, 20

| Room | Label | Function | Az | Pz | ASHRAE 62.1-2004 | | Az*Ra | Pz*Rp | Voz | Vpz | Zp | Vou | Vps | Zp(max) | Ev | Vot | Designed OA |
|------------|-------|----------|-----|----|------------------|----|-------|-------|------|-----|------|------|-----|---------|----|------|-------------|
| | | | | | Assumed | Ra | | | | | | | | | | | |
| Tey Office | 321 | Office | 173 | 1 | 0.06 | 5 | 10.4 | 5 | 15.4 | 290 | 0.05 | | | | | | |
| Total | | | | | | | | | | | | 15.4 | 290 | 0.05 | 1 | 15.4 | 20 |

References

ASHRAE. 2004, ANSI/ASHRAE, Standard 62.1 – 2004, Ventilation for Acceptable Indoor Air Quality. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA. 2004.

Paul H. Yeomans, Inc. 2004, Mechanical Construction Documents. Paul H. Yeomans, Inc., Philadelphia, PA. 2004.