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Executive Summary

In December of 2020, Strategic Energy Solutions submitted our review of the outdoor air requirements for teaching spaces located within Grand Rapids Public Schools building. In that report, we indicated there were certain schools which met LEED requirements, and therefore, required no additional analysis or adjustment. Upon review by the school district, it was determined that 8 of these schools would be reviewed further, to show their outdoor air requirements are being met.

The outdoor air calculation was performed in accordance with the 2015 Michigan Mechanical Code (MMC) which is the current legal code for new mechanical systems in the state. The 2015 MMC requires a minimum outdoor airflow per person in addition to a minimum outdoor airflow per square foot. The 2015 MMC does not require a minimum air change rate per hour of either total supply air or outdoor air for school buildings. Existing floor plans were used to determine which spaces were teaching spaces/classrooms. The schools were classified in to six categories, and during this analysis it was determined that:

- 5 schools meet requirements for outdoor airflow and require no adjustment.
- 3 schools have no existing TAB report and cannot be determined if adjustments are required.
- 1 school requires some adjustment to either outdoor airflow or occupant counts.

A more detailed analysis of these findings can be found in the report and appendices contained within.
Scope Summary

Strategic Energy Solutions (SES) was tasked with evaluating the outdoor air requirements for each of the teaching spaces located within the Grand Rapids Public Schools’ LEED certified buildings. The following schools were evaluated:

**Elementary Schools**
- Buchanan Elementary
- Burton Elementary/Middle
- Cesar E. Chavez Elementary
- Gerald R. Ford Elementary
- Harrison Park School
- Sibley Elementary

**Middle Schools**
- Blanford Middle

**High Schools**
- City High – CFE Building
- Museum High
**Existing Systems**

The existing mechanical systems vary from school to school. Across the district, there are three main system types:

1. **Unit Ventilator (UV):** These units handle all of their own outdoor airflow. Typically, one UV will serve one classroom space. The sum of OA for that space is handled by its respective UV.

2. **Single Zone Roof Top Unit (RTU):** This system is a larger version of a unit ventilator when serving a single space. The outdoor air required for the space is handled by the one unit that serves the respective space. These systems are typical for gyms throughout the district.

3. **Multi Zone Roof Top Unit/ Air Handling Unit with Variable Air Volume boxes (RTU/AHU w/ VAV):** These systems rely on one large air handling unit supplying air to numerous VAV boxes. Each VAV modulates airflow into a space to maintain space temperature. The outdoor air for this system is handled by the RTU/AHU. All outdoor air requirements for each space served by that RTU/AHU are calculated to determine the minimum outdoor air required for that unit.

**Outdoor Air Calculations**

Each teaching space was compared against the current Michigan Mechanical Code (MCC-2015). Section 403 of the MCC indicates the procedure for evaluating the minimum outside air (OA) required based on the usage of the space. The chart has been attached for reference in Appendix C. To meet the current code requirements, a space must be supplied with a minimum airflow (cubic feet per minute, CFM) of OA per person and per square foot. The code indicates occupancy of each space regarding ventilation requirements in the form of people per one-thousand square feet (PPL / 1000 SF). For all schools indicated in this scope of work, this is how the occupancy of each space was determined.

To perform the calculation, the following assumptions were made:

1. **During heating mode,** the air temperature into the space is less than or equal to 15°F above the space temperature set point.

2. **For systems that are VAV or terminal units (TU),** the minimum outside air was calculated assuming the entire system is operating.

3. **For systems that are VAV or TU,** the minimum airflow for VAV/TU is correctly sized to ensure all OA is getting to each space even during minimum airflow setpoint.

4. **For systems that only served office spaces,** their OA was not evaluated since they are non-classroom spaces. If an RTU/AHU included both classrooms and offices, their OA was evaluated.

Existing floor plans for each school were used to determine the OA required for each space. Based on room size and typical school functions, assumptions were made to determine the MMC classification for each space, therefore determining the calculated OA for each space. Each floor plan has been included as part of this report in Appendix B. Every teaching/instructional space has an OA calculation tag associated with it. A sample tag is detailed below.
Dashed lines around spaces indicate the extent of each zone (i.e. the area one VAV/TU box serves, or the area one UV serves). Hatching lines within a space help designate which RTU serves that space. A sample RTU tag with OA requirements is below.

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**Summary of Findings**

Tables including all schools reviewed have been provided in Appendix A. These tables have a color-coded key indicating their classification in terms of if they meet OA requirements or if they will require adjustments made at either the RTU/AHU or the UV. The final column indicates a summary of what steps could be taken to meet the OA requirements if they are not met.

As noted in the previous report, all the schools evaluated as part this report are, according the GRPS, LEED certified schools (please see note regarding City High – CFE Building below). In order to meet the requirements of LEED, the building must meet the minimum OA requirements per local code and ASHRAE 62.1. Therefore, any certification level (Certified, Silver, Gold, etc.) will have adequate ventilation. A school **cannot** be certified without the HVAC system sized to handle and distribute adequate ventilation to the school. Because of this, the best way for the district to ensure adequate
ventilation is provided, is to review the original documents for the buildings. If all the systems’ airflows are balanced to the original documents, adequate ventilation will be provided.

Five out of nice schools evaluated in this study had existing TAB reports which, when compared to OA calculations, indicated enough ventilation was being provided.

The following schools, which stood out when going through the calculation procedure, are unique and required further explanation.

**Blanford and Cesar Chavez**
These schools do not have an existing TAB report. Their OA was evaluated for known spaces; assumptions were made for the remaining spaces and indicated in APPENDIX B. With an existing TAB report, further analysis can be provided. However, since these are LEED certified schools, if their current airflow measurements at each AHU match that of the original drawings, no adjustments will be needed.

**Burton**
There are numerous spaces included/not included in the TAB report, but shown on the floor plans and vice versa. Based on their location in the building, assumptions were made regarding which AHU serves each space. The total airflow requirements for each AHU reflects the OA requirement with/without these assumptions.

**Harrison Park**
There are a couple AHU’s serving the elementary side of the building which appear to be short on OA. However, the TAB report indicates the OA ductwork can handle 100% OA at the unit. A controls contractor should verify the minimum OA damper position will allow for the minimum OA as noted in APPENDIX B.

**City High CTE Building**
There is no existing TAB report for this school. The OA has been evaluated for known spaces and indicated in APPENDIX B. With an existing TAB report, further analysis can be provided. This is not a known LEED building. In the absence of an existing TAB report, airflow measurement of OA at the equipment serving this building will be required to understand whether there is sufficient airflow.

Caution needs to be exercised when adjusting the OA to a unit. Increasing the OA of a unit higher than the designed airflow could potentially freeze the coil during the winter or negatively impact space humidity during the early and late summer. Spaces where the OA is adjusted should be monitored to ensure the space temperature is being met after the OA adjustment is made. A monitoring period should extend through all seasons.

Two of the main steps which can be taken to correct the OA are either reducing the student count (based on the code occupancy) in each space to meet the existing TAB report measurements or adjusting the OA CFM to meet the requirements of each space (based on the code occupancy).

The most direct means to meet the existing TAB measurements is to reduce people count. Typically, one person in a classroom space is equivalent to 10 CFM of OA. An example would be if the existing TAB
# ELEMENTARY SCHOOLS

<table>
<thead>
<tr>
<th>SCHOOL</th>
<th>GRADES</th>
<th>2019-2020 ENROLLMENT</th>
<th>YEAR BUILT</th>
<th>YEAR MODIFIED</th>
<th>TAB (Y/N)</th>
<th>TAB REPORT YEAR</th>
<th>SYSTEM</th>
<th>STEPS MOVING FORWARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUCHANAN</td>
<td>PreK-5</td>
<td>425</td>
<td>1962</td>
<td>Y</td>
<td>2018</td>
<td>UV</td>
<td>ALL TEACHING/INSTRUCTION SPACES MEET VENTILATION REQUIREMENTS.</td>
<td></td>
</tr>
<tr>
<td>BURTON</td>
<td>PreK-8</td>
<td>1016</td>
<td>1926</td>
<td>Y</td>
<td>2008</td>
<td>2009 AHU / TERM. U'S</td>
<td>ALL SPACES INDICATED IN THE EXISTING TAB REPORT HAVE BEEN INDICATED IN APPENDIX B. BASED ON TAB REPORT, ALL TEACHING/INSTRUCTION SPACES MEET VENTILATION REQUIREMENTS.</td>
<td></td>
</tr>
<tr>
<td>CESAR E. CHAVEZ</td>
<td>PreK-5</td>
<td>403</td>
<td>2007-2008</td>
<td>N</td>
<td>VAV</td>
<td>OA REQUIREMENTS HAVE BEEN NOTED IN APPENDIX B. THERE IS NO EXISTING TAB REPORT TO CONFIRM EXISTING AIRFLOW AND IF ADJUSTMENTS ARE REQUIRED.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GERALD R. FORD</td>
<td>PreK-8</td>
<td>303</td>
<td>1952</td>
<td>Y</td>
<td>2013</td>
<td>VAV</td>
<td>ALL TEACHING/INSTRUCTION SPACES MEET VENTILATION REQUIREMENTS. REVIEW GYM AND CAFETERIA - ARE THESE NON INSTRUCTIONAL SPACES?</td>
<td></td>
</tr>
<tr>
<td>HARRISON PARK</td>
<td>PreK-8</td>
<td>594</td>
<td>1925</td>
<td>Y</td>
<td>2008</td>
<td>VAV</td>
<td>OA REQUIREMENTS HAVE BEEN NOTED IN APPENDIX B. ELEMENTARY CLASSROOM UNITS APPEAR TO BE SHORT, BASED ON TAB REPORT. HOWEVER, TAB REPORTS INDICATE THE UNITS CAN HANDLE MORE OA. NEED TO CONFIRM WITH EXISTING MECHANICAL PLANS.</td>
<td></td>
</tr>
<tr>
<td>SIBLEY</td>
<td>PreK-5</td>
<td>328</td>
<td>2006</td>
<td>Y</td>
<td>2006</td>
<td>VAV</td>
<td>ALL TEACHING/INSTRUCTION SPACES MEET VENTILATION REQUIREMENTS.</td>
<td></td>
</tr>
</tbody>
</table>
MIDDLE SCHOOLS

<table>
<thead>
<tr>
<th>SCHOOL</th>
<th>GRADES</th>
<th>2019-2020 ENROLLMENT</th>
<th>YEAR BUILT</th>
<th>YEAR MODIFIED</th>
<th>TAB (Y/N)</th>
<th>TAB REPORT YEAR</th>
<th>SYSTEM</th>
<th>STEPS MOVING FORWARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLANFORD MIDDLE</td>
<td>6</td>
<td>59</td>
<td>2012</td>
<td>N</td>
<td></td>
<td></td>
<td>HEATPUMP/ERV</td>
<td>OA REQUIREMENTS HAVE BEEN NOTED IN APPENDIX B. THERE IS NO EXISTING TAB REPORT TO CONFIRM EXISTING AIRFLOW AND IF ADJUSTMENTS ARE REQUIRED.</td>
</tr>
</tbody>
</table>

NO EXISTING TAB REPORT TO REVIEW.
REQUIRES ADJUSTMENT TO OA SYSTEMS OK
<table>
<thead>
<tr>
<th>SCHOOL</th>
<th>GRADES</th>
<th>2019-2020 ENROLLMENT</th>
<th>YEAR BUILT</th>
<th>YEAR MODIFIED</th>
<th>TAB (Y/N)</th>
<th>TAB REPORT YEAR</th>
<th>SYSTEM</th>
<th>STEPS MOVING FORWARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CITY HIGH - CFE BUILDING</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N</td>
<td>N</td>
<td></td>
<td>VAV</td>
<td>OA REQUIREMENTS HAVE BEEN NOTED IN APPENDIX B. THERE IS NO EXISTING TAB REPORT TO CONFIRM EXISTING AIRFLOW AND IF ADJUSTMENTS ARE REQUIRED.</td>
</tr>
<tr>
<td>MUSEUM HIGH</td>
<td>9-12</td>
<td>143</td>
<td>N/A</td>
<td>Y</td>
<td>2018</td>
<td>VAV</td>
<td></td>
<td>ALL TEACHING/INSTRUCTION SPACES MEET VENTILATION REQUIREMENTS.</td>
</tr>
</tbody>
</table>
CAFETERIA
100 PPL/1000 SF
7.5 CFM/PERSON
0.18 CFM/SF
PEOPLE: 172.6
OA CFM = (7.5*173 PPL) + (0.18*1726 SF)
               = 1608.2

OFFICE
5 PPL/1000 SF
5 CFM/PERSON
0.06 CFM/SF
PEOPLE: 0.97
OA CFM = (5*1 PPL) + (0.06*173 SF)
               = 5.1

CLASSROOM (5-8)
25 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/SF
PEOPLE: 23.4
OA CFM = (10*24 PPL) + (0.12*936 SF)
               = 352.3
OFFICE - 214B
5 PPL/1000 SF
5 CFM/PERSON
0.06 CFM/ SF
PEOPLE: 0.6
OA CFM = (5*1 PPL) + (0.06*115 SF)
    = 12

OFFICE - 214A
5 PPL/1000 SF
5 CFM/PERSON
0.06 CFM/ SF
PEOPLE: 0.23
OA CFM = (5*1 PPL) + (0.06*46 SF)
    = 7.76

CLASSROOM (5-8)
25 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF
PEOPLE: 6.8
OA CFM = (10*7 PPL) + (0.12*272 SF)
    = 202.6

CLASSROOM (5-8)
25 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF
PEOPLE: 25.5
OA CFM = (10*26 PPL) + (0.12*1020 SF)
    = 382.4

CLASSROOM (5-8)
25 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF
PEOPLE: 27.5
OA CFM = (10*28 PPL) + (0.12*1100 SF)
    = 412

CLASSROOM (5-8)
25 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF
PEOPLE: 14
OA CFM = (10*14 PPL) + (0.12*560 SF)
    = 207.2

OFFICE
5 PPL/1000 SF
5 CFM/PERSON
0.06 CFM/ SF
PEOPLE: 0.3
OA CFM = (5*1 PPL) + (0.06*59 SF)
    = 8.54

MEDIA CENTER
25 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF
PEOPLE: 66.375
OA CFM = (10*67 PPL) + (0.12*2655 SF)
    = 989

APPENDIX B
APPENDIX B

CLASSROOM (9+)
35 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF
PEOPLE: 30.45
OA CFM = (10*31 PPL) + (0.12*870 SF)
               = 414.4

OFFICE
5 PPL/1000 SF
5 CFM/PERSON
0.06 CFM/ SF
PEOPLE: .4
OA CFM = (5*1 PPL) + (0.06*80 SF)
               = 9.8

CORRIDOR 
0.06 CFM/ SF
OA CFM = (0.06*2988 SF)
               = 179.28
PER CAPACITIES SPREAD SHEET:
3-6-8 grade classrooms on third floor.
Remainder of classrooms: Pre-K - 5th.
Will have safety factor on third floor for all spaces being 9+ age (align with code classification).
OVER/UNDER REQ.:

AHU-01 TEST: 1,943 **% NOT INDICATED
AHU-01 DESIGN: 2,000 CFM

NOT FOUND ON PLAN, BUT IN TAB
REPORT
TU-214 - NO ROOM NAME GIVEN
TU-215 - NO ROOM NAME GIVEN

TU-204
TOTAL SA: 2,360
TOTAL OA MIN: 385
0.12 CFM/ SF
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
PEOPLE: 25.875
OA CFM = (10*26 PPL) + (0.12*1035 SF)
               = 384.2
               = 384.2
TOTAL OA MIN: 385
TU-203
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
10  CFM/PERSON
2 5  PPL/1000 SF
TU-207
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 29.8
OA CFM = (10*25 PPL) + (0.12*1192 SF)
               = 393.04
               = 393.04
TOTAL OA MIN: 394
TU-202
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 21.85
OA CFM = (10*22 PPL) + (0.12*874 SF)
               = 324.88
               = 324.88
TOTAL OA MIN: 325
TU-205
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 21.85
OA CFM = (10*22 PPL) + (0.12*874 SF)
               = 324.88
               = 324.88
TOTAL OA MIN: 325
TU-208
TOTAL SA: 910
TOTAL OA MIN: 138
CORRIDOR
TU-201
TOTAL SA: 825
TOTAL OA MIN: 144
CORRIDOR
TU-209
TOTAL SA: 905
TOTAL OA MIN: 147
CORRIDOR
TU-206
TOTAL SA: 960
TOTAL OA MIN: 139
CORRIDOR
TU-207
TOTAL SA: 935
TOTAL OA MIN: 143
CORRIDOR
TU-210
TOTAL OA MIN: 325
TU-205
TOTAL OA MIN: 325
TU-208
TOTAL OA MIN: 138
TU-201
TOTAL OA MIN: 144
TU-209
TOTAL OA MIN: 147
TU-207
TOTAL OA MIN: 143
TU-210
TOTAL OA MIN: 325
TU-208
TOTAL OA MIN: 138
TU-201
TOTAL OA MIN: 144
TU-209
TOTAL OA MIN: 147
TU-207
TOTAL OA MIN: 143
TU-210
TOTAL OA MIN: 325
TU-208
TOTAL OA MIN: 138
TU-201
TOTAL OA MIN: 144
TU-209
TOTAL OA MIN: 147
TU-207
TOTAL OA MIN: 143
TU-210
TOTAL OA MIN: 325
AHU-3 RAW OA DATA: 1,393
AHU-3 DESIGN: 2,829 CFM
AHU-3 TEST: 3,340
OVER/UNDER REQ.: +1,947

OVER/UNDER REQ.:
AHU-3 TEST: 3,340
AHU-3 DESIGN: 2,829 CFM
AHU-3 RAW OA DATA: 1,393

= 1393
OA CFM = (0.3*4642 SF)
GYM (PLAY AREA) -
= 443
OA CFM = (10*37 PPL) + (0.06*1211SF)
PEOPLE: 36.33
10  CFM/PERSO N
35  PPL/1000 SF
MUSIC CLASSROOM **ASSUMED
TOTAL OA MIN: 443
TOTAL SA: 1,705
TU-503

AHU-1 RAW OA DATA: 3,812 REQ.
AHU-1 DESIGN: 8,850 CFM
AHU-1 TEST: 9,660
OVER/UNDER REQ.: +5,848

OVER/UNDER REQ.:
AHU-1 DESIGN: 8,850 CFM
AHU-1 RAW OA DATA: 3,812 REQ.
TU-109 - 118A (TOILET ON PLAN
NOT FOUND ON PLAN, BUT IN TAB
REPORT
TU-109 - 118A (TOILET ON PLAN
WOULD NOT NEED 700 CFM)

= 13.6
OA CFM = (5*1 PPL) + (0.06*144 SF)
PEOPLE: 0.72
0.06 CFM/ SF
5 CFM/PERSON
5 PPL/1000 SF
OFFICE

= 13.6
OA CFM = (5*1 PPL) + (0.06*144 SF)
PEOPLE: 0.72
5 CFM/PERSON
5 PPL/1000 SF
OFFICE

CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 22.5
OA CFM = (10*23 PPL) + (0.12*899 SF)
               = 337.8
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 22.45
OA CFM = (10*23 PPL) + (0.12*898 SF)
               = 337.76
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 23.93
OA CFM = (10*24 PPL) + (0.12*957 SF)
               = 354.94
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 22.45
OA CFM = (10*23 PPL) + (0.12*898 SF)
               = 337.76
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 19.3
OA CFM = (10*20 PPL) + (0.12*772 SF)
               = 292.61
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 19.3
OA CFM = (10*20 PPL) + (0.12*772 SF)
               = 292.61
PEOPLE: 22.5
OA CFM = (10*23 PPL) + (0.12*899 SF)
               = 337.8
CLASSROOM (5-8)
2 5  PPL/1000 SF
10  CFM/PERSON
0.12 CFM/ SF
PEOPLE: 22.45
OA CFM = (10*23 PPL) + (0.12*898 SF)
               = 337.76
PEOPLE: 23.93
OA CFM = (10*24 PPL) + (0.12*957 SF)
               = 354.94
PEOPLE: 22.5
OA CFM = (10*24 PPL) + (0.12*957 SF)
               = 354.94

TOTAL OA MIN: 14
TOTAL SA: 740
TU-114
TOTAL OA MIN: 14
TOTAL SA: 830
TU-112
TOTAL OA MIN: 395
TOTAL SA: 1,410
TU-115
TOTAL OA MIN: 395
TOTAL SA: 1,425
TU-116
TOTAL OA MIN: 395
TOTAL SA: 1,430
TU-107
TOTAL OA MIN: 355
TOTAL SA: 1,280
TU-104
TOTAL OA MIN: 338
TOTAL SA: 1,190
TU-103
TOTAL OA MIN: 338
TOTAL SA: 1,230
TU-101
TOTAL OA MIN: 293
TOTAL SA: 1,255
TU-105
TOTAL OA MIN: 338
TOTAL SA: 1,230
TU-102
TOTAL OA MIN: 14
TOTAL SA: 560
TU-106
TOTAL OA MIN: 395
TOTAL SA: 1,460
TU-110
TOTAL OA MIN: 383
TOTAL SA: 1,510
TU-111
TOTAL OA MIN: 14
TOTAL SA: 700
TU-113
TOTAL OA MIN: 395
TOTAL SA: 1,430
TU-118
TOTAL OA MIN: 395
TOTAL SA: 1,425
TU-119
TOTAL OA MIN: 14
TOTAL SA: 740
TU-114
TOTAL OA MIN: 14
TOTAL SA: 700
TU-111
TOTAL OA MIN: 14
TOTAL SA: 700

AHU-4: SERVES
EXCLUSIVELY 
NON CLASSROOM
SPACES. OA NOT
EVALUATED AT
THIS TIME.

TOTAL OA MIN: 293
TOTAL SA: 1,255
TU-101
TOTAL OA MIN: 338
TOTAL SA: 1,190
TU-104
TOTAL OA MIN: 338
TOTAL SA: 1,230
TU-103
TOTAL OA MIN: 338
TOTAL SA: 1,280
TU-107
TOTAL OA MIN: 355
TOTAL SA: 1,280
TU-104
TOTAL OA MIN: 338
TOTAL SA: 1,190
TU-103
TOTAL OA MIN: 338
TOTAL SA: 1,230
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TU-107
TOTAL OA MIN: 355
TOTAL SA: 1,280
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TOTAL OA MIN: 338
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TOTAL OA MIN: 338
TOTAL SA: 1,190
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TOTAL SA: 1,255
TU-105
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TU-105
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TOTAL SA: 1,230
TU-107
TOTAL OA MIN: 355
TOTAL SA: 1,280
TU-104
TOTAL OA MIN: 338
TOTAL SA: 1,190
TU-103
TOTAL OA MIN: 338
TOTAL SA: 1,230
TU-101
TOTAL OA MIN: 293
TOTAL SA: 1,255
TU-105
TOTAL OA MIN: 338
TOTAL SA: 1,230
TU-107
TOTAL OA MIN: 355
TOTAL SA: 1,280
TU-104
TOTAL OA MIN: 338
TOTAL SA: 1,190
TU-103
TOTAL OA MIN: 338
TOTAL SA: 1,230
TU-101
TOTAL OA MIN: 293
TOTAL SA: 1,255
TU-105
TOTAL OA MIN: 338
TOTAL SA: 1,230
TU-107
TOTAL OA MIN: 355
TOTAL SA: 1,280
TU-104
TOTAL OA MIN: 338
TOTAL SA: 1,190
TU-103
APPENDIX B
APPENDIX B

CLASSROOM (9+)
35 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF

PEOPLE: 27.13
OA CFM = (10*28 PPL) + (0.12*775 SF)
       = 373

OA CFM = (10*28 PPL) + (0.12*775 SF)

VAV-216
TOTAL SA: 540
TOTAL OA MIN: 373

CLASSROOM (9+)
35 PPL/1000 SF
10 CFM/PERSON
0.12 CFM/ SF

PEOPLE: 92.5
OA CFM = (10*93 PPL) + (0.12*2642 SF)
       = 1247.04

OA CFM = (10*93 PPL) + (0.12*2642 SF)

VAV-205
TOTAL SA: 590
TOTAL OA MIN: 373

VAV-211
TOTAL SA: 1,560
TOTAL OA MIN: 120

HRU-201 RAW OA DATA: 4,000 REQ.
HRU INDICATES HEAT RECOVERY UNIT; 100% OA UNIT.
TOTAL UNIT SUPPLY: 6,690
OVER/UNDER REQ.: +2,690

HRU-203 RAW OA DATA: 815 REQ.
HRU INDICATES HEAT RECOVERY UNIT; 100% OA UNIT.
TOTAL UNIT SUPPLY: 3,390
OVER/UNDER REQ.: +2,575

CORRIDOR
0.06 CFM/ SF
OA CFM = (0.06*410 SF)
       = 25

OA CFM = (0.06*410 SF)

CORRIDOR
0.06 CFM/ SF
OA CFM = (0.06*2000 SF)
       = 120

OA CFM = (0.06*2000 SF)

HRU-202 RAW OA DATA: 3,116 REQ.
HRU INDICATES HEAT RECOVERY UNIT; 100% OA UNIT.
TOTAL UNIT SUPPLY: 3,990
OVER/UNDER REQ.: +874
### TABLE 403.3.1.1
MINIMUM VENTILATION RATES

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>OCCUPANT DENSITY #/1000 FT²&lt;sup&gt;a&lt;/sup&gt;</th>
<th>PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R&lt;sup&gt;²&lt;/sup&gt; CFM/PERSON</th>
<th>AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, Ra CFM/FT²&lt;sup&gt;a&lt;/sup&gt;</th>
<th>EXHAUST AIRFLOW RATE CFM/FT²&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
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<tbody>
<tr>
<td>Correctional facilities</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Booking/waiting</td>
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<tr>
<td>Cells</td>
<td>25</td>
<td>5</td>
<td>0.12</td>
<td>-</td>
</tr>
<tr>
<td>without plumbing fixtures</td>
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<td>with plumbing fixtures</td>
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</tr>
<tr>
<td>Day room</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Dining halls</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(see food and beverage service)</td>
<td></td>
<td></td>
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<tr>
<td>Guard stations</td>
<td>15</td>
<td>5</td>
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<td>-</td>
</tr>
<tr>
<td>Dry cleaners, laundries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coin-operated dry cleaner</td>
<td>20</td>
<td>15</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Coin-operated laundries</td>
<td>20</td>
<td>7.5</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Commercial dry cleaner</td>
<td>30</td>
<td>30</td>
<td>-</td>
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<tr>
<td>Commercial laundry</td>
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<td>25</td>
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<tr>
<td>Storage, pick up</td>
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</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
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<tr>
<td>Art classroom&lt;sup&gt;g&lt;/sup&gt;</td>
<td>20</td>
<td>10</td>
<td>0.18</td>
<td>0.7</td>
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<tr>
<td>Auditoriums</td>
<td>150</td>
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<tr>
<td>Classrooms (ages 5-8)</td>
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<tr>
<td>Classrooms (age 9 plus)</td>
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<td>Computer lab</td>
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<tr>
<td>Corridors (see public spaces)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Day care (through age 4)</td>
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<td>0.06</td>
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<tr>
<td>Lecture hall (fixed seats)</td>
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<td>0.06</td>
<td>-</td>
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<tr>
<td>Locker/dressing rooms&lt;sup&gt;g&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.25</td>
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<tr>
<td>Media center</td>
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<td>10</td>
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<td>-</td>
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<tr>
<td>Multifunctional assembly</td>
<td>100</td>
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<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Music/theater/dance</td>
<td>35</td>
<td>10</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Science laboratories&lt;sup&gt;g&lt;/sup&gt;</td>
<td>25</td>
<td>10</td>
<td>0.18</td>
<td>1.0</td>
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<tr>
<td>Smoking lounges&lt;sup&gt;b&lt;/sup&gt;</td>
<td>70</td>
<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sports locker rooms&lt;sup&gt;g&lt;/sup&gt;</td>
<td>20</td>
<td>10</td>
<td>0.18</td>
<td>0.5</td>
</tr>
<tr>
<td>Wood/metal shops&lt;sup&gt;g&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td>0.5</td>
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<tr>
<td>Food and beverage service</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bars, cocktail lounges</td>
<td>100</td>
<td>7.5</td>
<td>0.18</td>
<td>-</td>
</tr>
<tr>
<td>Cafeteria, fast food</td>
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<td>7.5</td>
<td>0.18</td>
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<tr>
<td>Dining rooms</td>
<td>70</td>
<td>7.5</td>
<td>0.18</td>
<td>-</td>
</tr>
<tr>
<td>Kitchens (cooking)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
</tr>
<tr>
<td>Hotels, motels, resorts and dormitories</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bathrooms/toilet-private&lt;sup&gt;g&lt;/sup&gt;</td>
<td>10</td>
<td>5</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Bedroom/living room</td>
<td>50</td>
<td>5</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Conference/meeting</td>
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<td>5</td>
<td>0.06</td>
<td>-</td>
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<tr>
<td>Dormitory sleeping areas</td>
<td>120</td>
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<td>0.18</td>
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<tr>
<td>Gambling casinos</td>
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<td>7.5</td>
<td>0.06</td>
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<tr>
<td>Lobbies/prefunction</td>
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<td>5</td>
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<tr>
<td>Multipurpose assembly</td>
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<tr>
<td>Offices</td>
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<td></td>
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</tr>
<tr>
<td>Conference rooms</td>
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<td>5</td>
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</tr>
<tr>
<td>Main entry lobbies</td>
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<td>5</td>
<td>0.06</td>
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</tr>
<tr>
<td>Reception areas</td>
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<td>5</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Telephone/data entry</td>
<td>60</td>
<td>5</td>
<td>0.06</td>
<td>-</td>
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<tr>
<td>Private dwellings, single and multiple</td>
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<td></td>
<td></td>
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<tr>
<td>Garages, common for multiple units&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Kitchens&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>25/100&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>Living areas&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>

<sup>a</sup> Based upon number of bedrooms. First bedroom, 2; each additional 0.35 ACH but not less

<sup>b</sup> Based upon number of bedrooms. First bedroom, 2; each additional 0.35 ACH but not less

<sup>c</sup> Based upon number of bedrooms. First bedroom, 2; each additional 0.35 ACH but not less

<sup>d</sup> Based upon number of bedrooms. First bedroom, 2; each additional 0.35 ACH but not less

<sup>e</sup> Based upon number of bedrooms. First bedroom, 2; each additional 0.35 ACH but not less

<sup>f</sup> Based upon number of bedrooms. First bedroom, 2; each additional 0.35 ACH but not less
<table>
<thead>
<tr>
<th>Public spaces</th>
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<tr>
<td>Corridors</td>
<td>-</td>
<td>-</td>
<td>0.06</td>
<td>-</td>
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<tr>
<td>Courtrooms</td>
<td>70</td>
<td>5</td>
<td>0.06</td>
<td>-</td>
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<tr>
<td>Elevator car</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
</tr>
<tr>
<td>Legislative chambers</td>
<td>50</td>
<td>5</td>
<td>0.06</td>
<td>-</td>
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<tr>
<td>Libraries</td>
<td>10</td>
<td>5</td>
<td>0.12</td>
<td>-</td>
</tr>
<tr>
<td>Museums (children's)</td>
<td>40</td>
<td>7.5</td>
<td>0.12</td>
<td>-</td>
</tr>
<tr>
<td>Museums/ galleries</td>
<td>40</td>
<td>7.5</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Places of religious worship</td>
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<td>5</td>
<td>0.06</td>
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<td>Shower room (per shower head)</td>
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<td>-</td>
<td>-</td>
<td>50/20f</td>
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<td>Smoking lounges</td>
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<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Toilet rooms - public</td>
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<td>-</td>
<td>-</td>
<td>50/70f</td>
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<td>Dressing rooms</td>
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<td>Mall common areas</td>
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<td>Sales</td>
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<td>7.5</td>
<td>0.12</td>
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<tr>
<td>Shipping and receiving</td>
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<td>-</td>
<td>0.12</td>
<td>-</td>
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<td>Smoking lounges</td>
<td>70</td>
<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Storage rooms</td>
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<td>-</td>
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<td>Beauty salons</td>
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<td>Nail salons</td>
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<td>Bowling alleys (seating areas)</td>
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<td>Disco/dance floors</td>
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<td>Game arcades</td>
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<td>Gym, stadium, arena (play area)</td>
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<tr>
<td>Health club/aerobics room</td>
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<td>20</td>
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</tr>
<tr>
<td>Health club/weight room</td>
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<td>Ice arenas</td>
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<td>Without combustion engines</td>
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<td>Spectator areas</td>
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<td>Auditoriums (see education)</td>
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<tr>
<td>Lobbies</td>
<td>150</td>
<td>5</td>
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<tr>
<td>Stages, studios</td>
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<td>Ticket booths</td>
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<td>Transportation waiting</td>
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<tbody>
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<td>Darkrooms</td>
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<td>Photo studios</td>
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For SI: 1 cubic foot per minute = 0.0004719 m³/s, 1 ton = 908 kg, 1 cubic foot per minute per square foot = 0.00508 m³/(s • m²), °C = ([°F] - 32)/1.8, 1 square foot = 0.0929 m²
a. Based upon net occupiable floor area.

b. Mechanical exhaust required and the recirculation of air from such spaces is prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Item 3)

c. Spaces unheated or maintained below 50°F are not covered by these requirements unless the occupancy is continuous.

d. Ventilation systems in enclosed parking garages shall comply with Section 404.

e. Rates are per water closet or urinal. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.

f. Rates are per room unless otherwise indicated. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.

g. Mechanical exhaust is required and recirculation from such spaces is prohibited except that recirculation shall be permitted where the resulting supply airstream consists of not more than 10 percent air recirculated from these spaces. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Items 2 and 4).

h. For nail salons, each manicure and pedicure station shall be provided with a source capture system capable of exhausting not less than 50 cfm per station. Exhaust inlets shall be located in accordance with Section 502.20. Where one or more required source capture systems operate continuously during occupancy, the exhaust rate from such systems shall be permitted to be applied to the exhaust flow rate required by Table 403.3.1.1 for the nail salon.