Technical Report 1

201 Rouse Boulevard
The Navy Yard
Philadelphia, PA 19112

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Contents

Executive Summary

This technical report breaks down a building's compliance with ASHRAE Standards 62.1 and 90.1. The building used in this and all following thesis work is 201 Rouse Boulevard; a 84,500 sqft office building in Philadelphia, PA. ASHRAE Standard 62.1 deals with a building's Indoor Air Quality and Ventilation, while Standard 90.1 is the Energy Standard and determines the requirements for 201 Rouse's envelope, insulation, mechanical and power systems. This report uses the 2010 version of the ASHRAE standards.

201 Rouse Boulevard is a 4 story office building in a Corporate Park at the Philadelphia Navy Yard. To be completed in Q1 2015, 201 Rouse is being built by Turner Construction and was designed by DIGSAU. The building utilizes two primary, and one secondary, rooftop air handling DX coil/stepped electric heat units to condition the spaces; additionally there is the help of variable air volume boxes. The building has a minimum 25% min outside air system (can operate ato 100% OA) with a full air economizer. A building automation system controls the whole system with the help of a bevy of sensors.

62.1-2010 Ventilation for Acceptable Indoor Air Quality

To ensure that those in 201 Rouse Boulevard have sufficient air quality levels, the building has to meet this standard. Using section 5 of 62.1, the mechanical systems are analyzed for compliance with the required types of equipment and systems. 201 Rouse complies with all the specifications in 62.1 section 5. In Section 6 of 62.1 a ventilation rate analysis is performed to see as to whether 201 Rouse provides adequate ventilation. With a minimum outdoor air setting of 24.5% the mechanical system provides more than enough ventilation to provide acceptable indoor air quality.

90.1 -2010 Energy Standard for Buildings Except Low Rise Residential Buildings

To make sure that all the systems and equipment of 201 Rouse are within standards of energy efficiency, an analysis of 90.1 is performed. With a modern weatherized envelope and conventional mechanical system, 201 Rouse complies with nearly all of the designations for a building in its climate zone.

Building Overview

Name:

201 Rouse Boulevard

Location:

201 Rouse Boulevard
The Navy Yard
Philadelphia, PA 19112

Occupant:

Franklin Square Capital Partners

Function:

Class A Office, Cafe, fitness center

Size:

84,500 sqft.

Construction:

September 2013 till Q1 2015

Project Team:

Architects:

- DIGSAU (Primary Architect)
- Re:vision Architects (LEED Consultant)
- Francis Cauffman (Interior Architecture)
- Fury Design (Interior Design)

Engineers:

- Environetics (Structural Design)
- Pennoni Associates (Site and Civil)
- In Posse (Energy Consultants)

Owners:

- Liberty Property Trust (owner)
- Synterra Partners (Developers)

Construction:

- Turner Construction (General Contractor)

Mechanical System overview

Heating & Cooling

201 Rouse Boulevard's heating and cooling is provided via three rooftop packaged units in conjunction with 4 electric unit heaters (used at entrances and equipment spaces). The building's primary spaces are conditioned by two large 33,600 SCFM (standard cubic feet per min.) rooftop air handling units (AHUs) with variable frequency drives (VFDs) that provide up to 1,500 kBTU/hr cooling (using R-410A refrigerant and an Energy Efficiency Ratio of 9.8) and 750 kBTU/hr heating each. Both AHUs utilize a economizer system with the return air, more details available in the Controls summary. The third rooftop unit is a smaller 1,600 SCFM packaged unit that provides the condition for the bathrooms and building core. Additionally 201 Rouse Boulevard utilizes single duct Variable Air Volume (VAV) Terminals of four varying sizes; all with electric reheat coils. The locations of the VAVs have not been specified yet as the internal layout is not finalized.

Ventilation

The ventilation is handled by two rooftop exhaust fans, with additional localized exhaust provided by transfer fans. The rooftop units are belt driven centrifugal exhaust fans that provide 5,300 SCFM and 865 SCFM for toilet exhaust and janitor's closets (always on) respectfully. The smaller (~400 SCFM) Transfer fans handle the ventilation from the electric closets and machine rooms and is controlled by the space's thermostat. In addition to the exhaust systems, each of the two large rooftop AHUs have a return system with 27,500 SCFM capacity each. This air return system uses the mechanical shaft as the supply system and is integrated in the AHU with an economizer.

Controls

201 Rouse Boulevard has a standard control system. The primary space AHUs have four scheduling modes: occupied, unoccupied, morning warm-up, and morning cool-down. The smaller core AHU has only two scheduling modes, occupied or unoccupied. When in occupied modes, the control sequence maintains a minimum outside air flow (set by ASHRAE 62.1), manages the variable volume control of the supply and return fans using system air balancing, uses stepped electric resistance heating to maintain the temperature setpoint, and utilizes economizer cooling when the outdoor air enthalpy is lower than the return air enthalpy. When in unoccupied mode, the outside air dampers are closed and the AHUs cycle to maintain the discharge air temperature setpoints.

ASHRAE Standard 62.1-2010: Section 5. Systems and Equipment

5.1 Ventilation Air Distribution

The windows in 201 Rouse Boulevard are primarily inoperable, as such the main ventilation is the mechanical system.

In compliance with 5.1.1 and 5.1.3 the building documentation describes the minimum outside air flow and coolings economizer settings with flow requirements set by ASHRAE 62.1-2007 and International Mechanical Code 2009. This flow compliance is calculated in Section 6. The the rooftop air handling units have a minimum Outside air intake of 24.5%.

The plenum system of 201 Rouse boulevard was designed to accommodate both the supply and return airflow requirements of the building spaces and meets 5.1.2.

5.2 Exhaust Duct Location

Exhaust Ducts in the mechanical system that may convey potentially harmful contaminants are negatively pressured and the exhaust fans all have backdraft dampers so that exhaust air cannot leak into occupied spaces.

5.3. Ventilation System Controls

A complete ventilation control system in integrated into the Building Automation System (BAS) with the minimum outside air flow set by section 6 of the AHSRAE 62.1. This minimum outside air flow is measured by a air flow monitoring station that reports to the BAS.
Additionally the BAS has carbon dioxide sensors located in the largest office spaces of each floor, and if the system detects CO2 readings below readings of 700 PPM relative to the outside air the outside air intake will be increased in 10% increments until the readings are back above the setpoint.
The building also has two rooftop exhaust fans that operate continuously during occupied control modes.

5.4 Airstream Surfaces

The equipment specified in the mechanical drawings pass the the "Mold Growth and Humidity Test" and "Erosion Test" in UL 181, thus meeting 5.4.1 Resistance to Mold Growth and 5.4.2 Resistance to Erosion.

5.5 Outdoor Air Intakes

The outdoor air intakes of 201 Rouse Boulevard's mechanical system are integrated into the rooftop AHUs that do the primary conditioning of the building spaces. The rooftop space has 5 exhausts/vents. Of the five, the two primary exhaust fans handle only Class 1 Airstreams and therefore do not have a minimum distance from the intakes as this air is allowed to transfer and recirculate. The Class ¾ Air Exhaust from the ground floor kitchen is greater than the minimum separation distance of 30' (assuming worst case scenario of a commercial grease hood) from the closest air intake of AHU 1. Minimum Separation Distances determined from Appendix D, and exhaust classification from Appendix C.

5.6 Local Capture of Contaminants

There are no non-combustion equipment within 201 Rouse Boulevard; therefore ASHRAE 62.1 5.6 does not apply

5.7 Combustion Air

All of the fuel-burning appliances and equipment currently specced are outside the building. Though if the proposed cafe utilizes fuel-consuming appliances there is a proposed kitchen exhaust that discharges at the roof.

5.8 Particulate Matter Removal

In compliance with section 5.8 and ANSI/ASHRAE Standard 52.2, 201 Rouse Boulevard has filters of minimum efficiency reporting value (MERV) of 13 (minimum requirement is 6). These MERV 13 filters are upstream of the cooling coils in all three of the rooftop AHUs, and of hospital/general surgery grade.

5.9 Dehumidification Systems

5.9.1 Relative Humidity

The mechanical air-conditioning systems utilize a control sequence to manage building relative humidity, when the humidity sensors read in excess of 57.5% RH the system will override the discharge air reset sequence, resetting the discharge air temperature down one degree fahrenheit every 10 minutes till the relative humidity of the return air falls below 54% RH.

5.9.2 Exfiltration

The mechanical system control sequence dictates that the minimum outside air flow is measured by the outside air flow (return air) monitoring station, as such it maintains positive pressure, and reduces building infiltration.

5.10 Drain Pans

In accordance with 5.10.1-5.10.4 the drain pans of the mechanical equipment are sloped greater than 0.125 in/foot, have their outlets at the lowest points of the drain pan, are properly sealed, and are large enough to cover the water producing area of the equipment. Additionally the rooftop AHUs have sloped 2" diameter condensate lines that empty the drain pans into the building's drainage system.

5.11 Finned-Tube Coils and Heat Exchangers

All cooling coils in the mechanical system have adequate drain pans correctly placed covering all condensate producing coils for compliance with 5.11.1. The 5 coil rows of the 2 larger AHUs and the 3 rows of coils of the smallest AHU are all spaced with access space of 18 in. to comply with 5.11.2.

5.12 Humidifiers and Water-Spray Systems

The mechanical conditioning systems of the building lack any humidification or water-spray systems and are therefore exempt from this section.

5.13 Access for Inspection, Cleaning and Maintenance

The building's mechanical systems comply with 5.13.1, 5.13.2 and 5.13.3 by providing easy access and a sizable clearance area around the rooftop mechanical zone, with additionally means of access (all sized appropriately) to the Ventilation and air distribution equipment throughout the building; allowing for the inspection cleaning and maintenance of all these systems.

5.14 Building Envelope and Interior Surfaces

5.14.1 Building Envelope

All facades and wall systems of the building are adequately weatherized to prevent water penetration across the envelope and vapor diffusion within the envelope. All envelope penetrations will be correctly filled in to create a continuous seal to

reduce uncontrolled entry of outdoor moisture and pollutants.

5.14.2 Condensation on Interior Surfaces

All interior surfaces of the mechanical equipment will be covered with insulation wrap or rigid board to abate the formation of condensation on the exposed surfaces and within the insulating material.

5.15 Buildings With Attached Parking Garages

There is no attached parking at 201 Rouse Boulevard, and as such ASHRAE 62.1 5.15 is not applicable.

5.16 Air Classification and Recirculation

As the building in currently specced out, there would only be Class 1 airflows (low contaminants and sensory irritation) from the office spaces and thus the airflows can be recirculated or transferred to any space per 5.16.2 and 5.16.3. There is capacity on the ground floor for the addition of the Class 3 or 4 airstreams that come from a commercial kitchen; this is achieved by a direct exhaust where these airflows wouldn't be recirculated or transferred to other spaces. See appendix A for a table on Airstream classifications.

5.17 Requirements for Buildings Containing ETS Areas and ETS-Free Areas

201 Rouse Boulevard is to be a smoke-free facility, as such is a wholly Environmental Tobacco Smoke (ETS) Area, and therefore section 5.17 of ASHRAE 62.1 5.17 is not applicable.

ASHRAE Standard 62.1-2010: Section 6. Procedures

The Ventilation Rate Procedure of 62.1.6 is used to determine the minimum outdoor airflow rates for a building. The whole building's mechanical system was analyzed, especially simple since the primary office zones have not been designed yet and the system is treating it as one large space.

6.2 Ventilation Rate Procedure

6.2.1 Outdoor Air Treatment

As discussed in 4.1 there are no issues with outdoor air quality from building exhausts and the filtration system is beyond competent to cover particulate matter.

6.2.2 Zone Calculations

6.2.2.1 Breathing Zone Outdoor Airflow

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z$$

Where:

- V_{bz} = the breathing zone outdoor airflow
- A_z = zone floor area (net occupiable) [ft.]
- R_a = Outdoor airflow rate required per unit area per unit area from ASHRAE Standards 62.1 Table 6.1 [CFM/ft^2]
- P_z = Zone population [persons]
- R_p = Outdoor airflow rate required per unit area per person from ASHRAE Standards 62.1 Table 6.1 [CFM/person]

6.2.2.3 Zone Outdoor Airflow

Zone outdoor Airflow (V_{OZ})

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

Zone Air Distribution Effectiveness (E_z) from ASHRAE 62.1 Table 6.2

E_z=1.0

6.2.3 Single Zone Systems

For Single Zone systems where the air handler(s) supply a mixture of outdoor air and recirculated air to a single space.

$V_{OT}=V_{OZ}$

6.2.5 Multiple-Zone Recirculating Systems

While the RTUs serve multiple zones they are either the same in space and function, or a combination of occupied and unoccupied spaces; so the single zone calculation can be used.

6.2.5.1 Primary outdoor Air Fraction (Z_p)

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

See Appendix A for analysis tables.

6.5 Exhaust Ventilation

See appendix A for Calculations and Table 6-4

All spaces within 201 Rouse meet the minimum exhaust rates specified.

Summary of 62.1

201 Rouse does a promising job of meeting all the requirements of ASHRAE 62.1 section 5. Often the building's design goes beyond the requirements, see mechanical controls and particulate matter removal. The only area that 201 could get into trouble is in the future design of a ground floor kitchen space, for there might not be enough exhaust and/or the exhaust might be too close to the intake of RTU 2.

All of the spaces in 201 Rouse have adequate ventilation per section 6's requirements. The overall min Outside air of the rooftop Air Handling Units is 24.5% by design and far surpasses the overall min required of ~5%. With this much overhead in extra ventilation it most likely will not matter what the office spaces get designed as.

ASHRAE Standard 90.1-2010

90.1 Section 5: Building Envelope

5.1 General:

5.1.4 Climate:

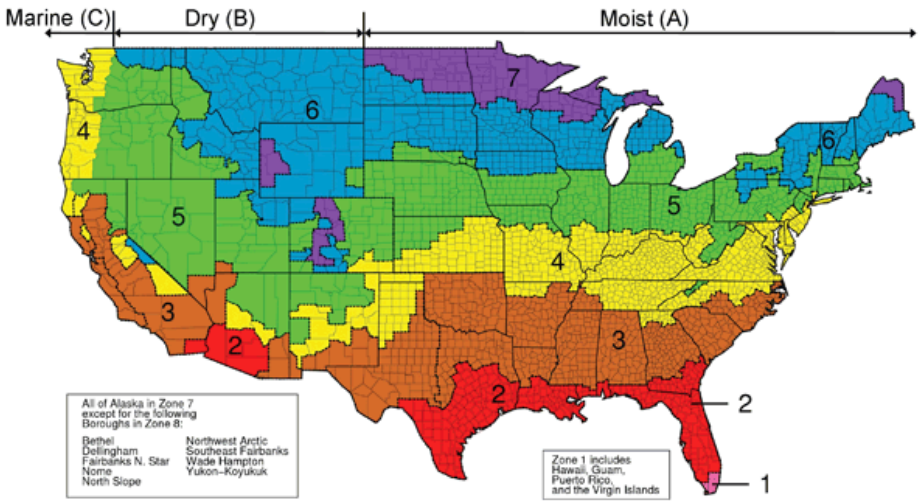

Figure 1 : ASHRAE 90.1 Climate Zone Map of the Continental USA

Located in Philadelphia, PA 201 Rouse Boulevard is in climate zone 4A, which is described as Mixed-Humid and has thermal criteria of CDD50ºF≤4500 and 3600<HDD65ºF≤5400.

5.2 Compliance Paths:

201 Rouse Boulevard is following the Building Envelope Compliance Path, whereas it must comply with sections 5.1, 5.4, 5.7, 5.8 and 5.5 if it meets the following criteria:

- Vertical fenestration <40% of Gross Wall area
- Skylight fenestration < 5% of Gross Roof Area

5.4 Mandatory Provisions

The vestibule entrances to 201 Rouse Boulevard have a longer span between the exterior and interior doors than the 7 tft. required by 5.4. Additionally the facade and fenestrations were all designed to create a continuous air barrier.

5.5 Prescriptive Building Envelope Option

Following the Building Envelope Compliance Path (5.2), the Prescriptive Building Envelope Option will be utilized. Table 1 shows that 201 Rouse Boulevard meets the fenestration requirements of this Envelope Option, while Table 2 shows the U value compliance for materials in Non Residential conditioned spaces in Climate Zone 4A.

Table 1: Building Gross Wall Area vs Fenestrations

Fenestration Area	Gross Surface Area	Percentage Glazing	Compliance
14, 400 sqft	41,550 sqft	~35%	Yes
0 sqft skylight	-- sqft Roof Area	--	Yes

Table 2: Building and Glazing Material Properties

Material	Maximum U-Value	Designed U-Value	Compliance
Roof	U-0.048	U-0.026	Yes
Zinc Facade Walls	U-0.064	U-0.0476	Yes
Windows	U-0.5	U-0.48	Yes
Floors	U-0.087	N/A	N/A

90.1 Section 6: Heating, Ventilating, and Air Conditioning

6.2 Compliance Path

The HVAC systems of 201 Rouse Boulevard will meet ASHRAE 92.1 requirements for Heating Ventilation and Air Conditioning by the mandatory provisions (6.4) and the Prescriptive Path (6.5)

6.4 Mandatory Provisions

6.4.1.1 Minimum Equipment Efficiencies

Table 3: Efficiency of Packaged Air Handlers

Packaged terminal Air Conditioner	Minimum Efficiency	Actual Efficiency	Compliance
RTU-1&2	~10.5 EER	9.8	No
RTU-3	N/A	N/A	N/A

Minimum Efficiency is set by Table 6.8.1D of AHSARE 92.1 Building system does not meet compliance, though the db rating condition of the outside air is ~10 deg F higher than the specced system from 201 Rouse Boulevard.

6.4.3 Controls

201 Rouse Boulevard has a comprehensive control sequences that allows for occupied and unoccupied modes, outdoor air damper control, and modular control of the single zone VAVs (to in compliance of 6.4.3.10 with an ability to meet full zone outdoor air requirements).

6.5 Prescriptive Path

6.5.1 Economizers

Per 6.5.1 201 Rouse has a full capacity air economizer and the system can still provide 100% of the building's required air for cooling via outside air and can modulate to the building's minimum outside air usage based upon a differential dry bulb reading.

6.5.2 Simultaneous Heating and Cooling Limitation

The building's control system will use thermostatic controls to prevent reheating/recooling. There are exceptions that apply to the single zone VAVs in the building.

6.5.6 Energy Recovery

201 Rouse is not a 24 hour facility and as such it does not have to comply with the heat recovery requirements for service water heating of 6.5.6

6.5.7 Exhaust Systems

The Kitchen exhaust system/hood is currently just a future consideration in the design of 201 Rouse, but when designed there is enough capacity in the mechanical system to cover the hood's exhaust flow rate.

6.7 Submittals

Full construction documents, along with operation and maintenance manuals will

be turned over the owner upon completion of the building in Q1 2015. Commissioning upon the building is being and will be completed post construction for LEED certification.

90.1 Section 7: Service Water heating

Section 7 covers service water heating for new and existing buildings. All the hot water piping within the building is insulated. However the current revision of construction documents do not contain the sizing of the domestic hot water heater, though it will be an electric heater less than 12kW and per table 7.8 in Appendix E it will most likely pass the efficiency requirements.

90.1 Section 8: Power

Power at 201 Rouse meets all requirements of AHSRAE 90.1.8. The 13.2 KVA transformer has an efficiency greater than the minimum 97.0% specified by Table 8.1 in Appendix F, and all circuits are sized beyond the maximum voltage drop of 3%. All Electric Design Documents are to be submitted to owner upon completion of the project.

90.1 Section 9: Lighting

201 Rouse is an office building and has a lighting power density (using the building area method of 9.5.1) of 0.9 W/ft^2. The building exterior is in zone 3 per Table 9.4.3A in Appendix G, and with that has the following individual lighting power allowances for the exterior (from table 9.4.3 B in Appendix G):

- Parking: 0.10W/ft^2
- Grounds: 0.16W/ft^2
- Entrances: 0.4W/ft^2

The Lighting design of 201 Rouse has all the power densities within these allowances though only the building core and bathrooms have been specced out as the tenant requirements are not developed yet, so that may change.

90.1 Section 10: Other Equipment

All additional motors in 201 Rouse comply with the "minimum nominal Efficiency for General Purpose Design A and Design B Motors." 201 Rouse also contains two elevators that comply with 10.4.3 with adequate lighting, ventilation, and a standby mode.

Summary of 90.1

201 Rouse Boulevard is compliant with ASHRAE 90.1's requirements for a building in Climate Zone 4A. Following the Prescriptive Building Envelope Option, the building's envelope is within standards, except for the floor where the U value was undetermined. Under the standard equipment of the HVAC section the engineering efficiency ratio (EER) of the rooftop AHUs was high, although the system that was specced out was different than the default system the standard used. The service water heater has not been specced out yet for 201 Rouse, however given the low demand of the building and its electric nature it will meet the standard. All of the power, lighting and other equipment were designed with the ASHRAE standard in mind and meet all of its criteria.

Appendix

Appendix

Appendix A: Ventilation Rate Analysis

Room Number	Name	Area (Az)	Function	Floor Area per Occupant	Design Occupancy (Pz)	Rp (CFM/person)	Ra (CFM/sqft)	Breathable Zone Outdoor Airflow (Vbz) [CFM]	Zone Air Distribution Effectiveness (Ez)	Voz
101	Lobby	1,300	Lobby	100	13	5	0.06	71	1	71
116	Tennant	3,700	Office Space	100	37	5	0.06	192	1	192
115	Tenant	9,700	Office Space	100	97	5	0.06	492	1	492
201	Tenant	18,900	Office Space	100	189	5	0.06	957	1	957
300	Tenant	18,900	Office Space	100	189	5	0.06	963	1	963
401	Tenant	18,900	Office Space	100	189	5	0.06	969	1	969

Room Number	Name	Voz	Minimum Provided Ventilation (Vpz min)* [CFM]	Compliance	Maximum Provided Ventilation (Vpz)	Primary outdoor Air Fraction (Zp) [%]
101	Lobby	71	183.75	Yes	750	9.47%
116	Tennant	192	1519	Yes	6200	3.10%
115	Tenant	492	4123.35	Yes	16830	2.92%
201	Tenant	957	4123.35	Yes	16830	5.69%
300	Tenant	963	4123.35	Yes	16830	5.72%
401	Tenant	969	4385.5	Yes	17900	5.41%

	Voz	Minimum Provided Ventilation (Vpz min)* [CFM]	Maximum Provided Ventilation (Vpz)	Required Primary outdoor Air Fraction (Zp) [%]
Totals	3644.04	18458.3	75340	4.84

1. Floor Area per Occupant from Design Occupancy per IBC 2009
2. Minimum Provided Ventilation Vpz is set by 24.5% Min OA intake at Air Handling Units

Appendix B: Airstream Classifications

Exhaust Space	Exhaust Rate [CFM/unit]	Exhaust Rate [CFM/sqft]	Units	Area	Minimum Exhaust Rate	Available Exhaust Rate	Compliance?
Mens Bathroom	50	-	5	-	250	600	Yes
Womens Bathroom	50	-	5	-	250	600	Yes
Janitors Closet	-	1	-	40	41	150	Yes
Recycling Room	-	1	-	260	261	265	Yes
Unisex Bathroom	70	-	1		70	170	Yes

TABLE 6-4 Minimum Exhaust Rates

Occupancy Category	Exhaust Rate, cfm/unit	Exhaust Rate, cfm/ft^2	Notes	Exhaust Rate, L/s·unit	Exhaust Rate, L/s·m^2	Air Class
Arenas	–	0.50	B	–	–	1
Art classrooms	–	0.70		–	3.5	2
Auto repair rooms	–	1.50	A	–	7.5	2
Barber shops	–	0.50		–	2.5	2
Beauty and nail salons	–	0.60		–	3.0	2
Cells with toilet	–	1.00		–	5.0	2
Copy, printing rooms	–	0.50		–	2.5	2
Darkrooms	–	1.00		–	5.0	2
Educational science laboratories	–	1.00		–	5.0	2
Janitor closets, trash rooms, recycling	–	1.00		–	5.0	3
Kitchenettes	–	0.30		–	1.5	2
Kitchens—commercial	–	0.70		–	3.5	2
Locker/dressing rooms	–	0.25		–	1.25	2
Locker rooms	–	0.50		–	2.5	2
Paint spray booths	–	–	F	–	–	4
Parking garages	–	0.75	C	–	3.7	2
Pet shops (animal areas)	–	0.90		–	4.5	2
Refrigerating machinery rooms	–	–	F	–	–	3
Residential kitchens	50/100	–	G	25/50	–	2
Soiled laundry storage rooms	–	1.00	F	–	5.0	3
Storage rooms, chemical	–	1.50	F	–	7.5	4
Toilets—private	25/50	–	E	12.5/25	–	2
Toilets—public	50/70	–	D	25/35	–	2
Woodwork shop/classrooms	–	0.50		–	2.5	2

A Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.
B When combustion equipment is intended to be used on the playing surface additional dilution ventilation and/or source control shall be provided.
C Exhaust not required if two or more sides comprise walls that are at least 50% open to the outside.
D Rate is per water closet and/or urinal. Provide the higher rate where periods of heavy use are expected to occur, e.g., toilets in theatres, schools, and sports facilities. The lower rate may be used otherwise.
E Rate is for a toilet room intended to be occupied by one person at a time. For continuous system operation during normal hours of use, the lower rate may be used. Otherwise use the higher rate.
F See other applicable standards for exhaust rate.
G For continuous system operation, the lower rate may be used. Otherwise use the higher rate.

Appendix C: Airstream Classifications

TABLE 5-2 Airstreams

Description	Air Class
Diazo printing equipment discharge	4
Commercial kitchen grease hoods	4
Commercial kitchen hoods other than grease	3
Laboratory hoods	4
Residential kitchen vented hoods	3
Hydraulic elevator machine room	2

Appendix D: Air Intake Minimum Separation Distances

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."

Appendix E: performance Requirements for Water Heating Equipment

TABLE 7.8 Performance Requirements for Water Heating Equipment

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required [a]	Test Procedure[b,c]
Electric table top water heaters	≤12 kW	Resistance ≥20 gal	0.93–0.00132V EF	DOE 10 CFR Part 430
Electric water heaters	≤12 kW	Resistance ≥20 gal	0.97–0.00132V EF	DOE 10 CFR Part 430
	>12 kW	Resistance ≥20 gal	$20 + 35\sqrt{V}$ SL, Btu/h	Section G.2 of ANSI Z21.10.3
	≤24 Amps and ≤250 Volts	Heat Pump	0.93–0.00132V EF	DOE 10 CFR Part 430

Appendix F: Minimum Efficiency for Distribution Transformers

TABLE 8.1 Minimum Nominal Efficiency Levels for NEMA Class I Low-Voltage Dry-Type Distribution Transformers[a]

Single Phase Transformers		Three Phase Transformers	
kVA[b]	Efficiency,%[c]	kVA[b]	Efficiency,%[c]
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
		750	98.8
		1000	98.9

[a] A low voltage distribution *transformer* is a *transformer* that is air-cooled, does not use oil as a coolant, has an input voltage ≤ 600 Volts, and is rated for operation at a frequency of 60 Hz.
[b] kiloVolt-Amp rating.
[c] Nominal efficiencies shall be established in accordance with the NEMA TP-1 2002 test procedure for low voltage *dry-type transformers*. Class I Low Voltage Dry-Type is a National Electrical Manufacturers Association (NEMA) design class designation.

Appendix G: Lighting Requirements

TABLE 9.4.3A Exterior Lighting Zones

Lighting Zone	Description
0	Undeveloped areas within national parks, state parks, forest land, rural areas, and other undeveloped areas as defined by the *authority having jurisdiction*
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of *residential* zoning, neighborhood business districts, light industrial with limited nighttime use and *residential* mixed use areas
3	All other areas
4	High activity commercial districts in major metropolitan areas as designated by the local jurisdiction

TABLE 9.4.3B Individual Lighting Power Allowances for Building Exteriors

	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (base allowance may be used in tradable or non-tradable surfaces)					
	No Base Site in Zone 0	500 W	600 W	750 W	1300 W
Tradable Surfaces (*LPD*s for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded.)					
Uncovered parking areas					
Parking areas and drives	No allowance	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
Building grounds					
Walkways less than 10 ft wide	No allowance	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
Walkways 10 ft wide or greater Plaza areas Special feature areas	No allowance	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.2 W/ft^2
Stairways	No allowance	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
Pedestrian tunnels	No allowance	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2
Landscaping	No allowance	0.04 W/ft^2	0.05 W/ft^2	0.05 W/ft^2	0.05 W/ft^2
Building entrances and exits					
Main entries	No allowance	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
Other doors	No allowance	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
Entry canopies	No allowance	0.25 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2

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