BSR/ASHRAE/IES Addendum bo
to ANSI/ASHRAE/IES Standard 90.1-2019

Public Review Draft

Proposed Addendum bo to Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings

First Public Review (November 2021)
(Draft Shows Proposed Changes to Current Standard)

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(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum is an update to the fan power limits in Section 6.5.3.1. It is based on updates to California Title 24-2022, and the same team created this proposal with modifications to meet the cost-effectiveness requirements determined using the standard process of SSPC 90.1. The increase in stringency ranges is, on average, about 10%, though the amount varies by fan system type.

The ASHRAE proposal has been presented to stakeholders twice. The first sessions were in April, where approximately 90 people attended over four sessions. The second round was in September, with about 60 attendees. It has also been reviewed several times by the Mechanical Subcommittee.

An updated stakeholder presentation that provides an in-depth explanation of how the new fan power allowances are calculated and explains in detail how they are applied is available here (link). A spreadsheet tool at the same link also allows users to calculate the difference in allowed fan power between the current requirements and those in this proposal for most typical fan systems. Finally, there will be stakeholder meetings held during the public review period.

The proposal solves many problems with the current requirements:

- The present method limits fan shaft power and does not consider the actual electric input power. Further, it does not cover the efficiency of the fan transmission, motor, or variable-speed controller. The proposal provides requirements for fan system electrical input power.
- The existing requirements are based on pressure losses for a large air handler (e.g., 3.5 in. w.c. for duct losses for a multizone system). This proposal provides requirements for small, medium, and large systems.
- Fan power limits do not apply to alterations. This proposal adds scope alterations with additional fan power allowances to account for existing duct systems and adapter curbs. Reviewers should note that direct replacement of existing fans is exempted from this requirement.
- New fan power allowances have been created for components that have become more common, including hot gas reheat coils, water economizer coils, and series energy recovery.
- The proposal recognizes the efficiency of using direct-drive instead of v-belt transmissions.
- Any supply fan that does not move air through a source of heating or cooling. For example, large energy recovery ventilators are out of scope. The scope would now cover these products.
- The existing language excludes fans that do not serve conditioned spaces. The proposal includes all fans serving interior spaces.

- The existing language includes only fan systems where the fan nameplate horsepower totals more than 5 hp. This excludes all fan systems up to approximately 5,000 cfm. The power threshold is reduced to 1 kW input power.

There are five steps to calculating the fan power budget:

1. Determine the type of fan system employed.
2. Determine the total fan power allowances in W/cfm from Tables 6.5.3.1-1 and -2.
3. Multiply the fan power allowances by the airflow in cfm (actual cfm, not standard cfm)
4. Divide by 1,000 to arrive at the allow input power in kW.
5. Apply the altitude correction factor for sites 3,000 feet or higher.

The electrical input power each fan or fan array in the system can be calculated in one of four ways:

- The information is supplied by the equipment manufacturer. This will be the typical scenario.
- If the motor nameplate horsepower is known, there is a table that provides default input power for systems with and without variable-speed drives.
- If the motor nameplate electrical input power is provided, that value can be used.
- If only the shaft input power is known, the electrical input power can be calculated using one of the methods in AMCA 208 – Fan Energy Index. This would be a last resort and rarely needed.

The input electrical power of all the fans in the fan system is summed and must be less than the fan power budget.

Cost-effectiveness

The proposed values reduce the allowed fan system electrical input power by about 10% on average, the amount varies by system. A large multi-zone VAV system will see a reduction of about 13% if it includes MERV-13 filters. On the other hand with the new credit for single-zone VAV systems that are configured to turn down to 50% of airflow, there is no increase in stringency at all.

There are many ways to improve a system to achieve the goal. Though the improvements here are based on the cost difference between a belt-drive centrifugal fan and a direct-drive plenum fan, there are many options to reduce pressure drop in the fan system that will yield the same results for less money. In fact, the California Title 24 cost-effectiveness was based entirely on improving the design of the duct system while leaving the current minimum-efficiency air handler systems unchanged. Some of the options for improving fan system performance include:

- Reducing duct pressure drop through the selection of high-performance fittings.
- Using angle filters in place of flat filters.
- Locating equipment so that duct runs, and in particular vertical shafts, are straight.
- Careful consideration of design and the placement of the first turn in the duct system after leaving the air handler (this is often the highest pressure drop in the system).

However, for the purpose of this exercise, the cost of a belt-driven centrifugal fan with a variable-frequency drive was compared to a direct-drive plenum fan. The reduction in transmission losses alone make up for most of the required improvement in electrical input power. The two systems were run in the prototype buildings used by ASHRAE 90.1 in all climate zones. The majority of fans in the prototype buildings that are large enough to meet the threshold of 1 kW of input power in the proposal are variable-speed fans. Manufacture cost data was used to compare the cost per design cfm of the two different fans at two different sizes:

- 3,000 cfm - $0.346 per cfm
- 10,000 cfm - $0.192 per cfm

The following tables show the annual energy cost savings for various buildings. The savings vary by climate, with warmer and wetter climates generally showing higher savings. The annual savings were multiplied by 12, which is the ASHRAE scalar limit for equipment with a 15-year lifespan. In nearly all cases, the cost per cfm of an improved fan is less than the scalar limit.

Primary school – these typically have fans that are about 3,000 cfm or a little more. In all cases, the savings are greater than the $0.346 additional cost:

	Elec Energy Savings (kWh)	Gas Energy Savings (Therm)	Elec Energy Cost Savings ($)	Gas Energy Cost Savings ($)	Total Energy Cost Savings ($)	Annual Savings X12	Modeled Airflow	$/cfm
Albuquerque	13085	-84	1438	-67	1371	$16,450	25169.5	$0.65
Atlanta	12935	-7	1422	-5	1416	$16,994	25169.5	$0.68
Buffalo	11531	-51	1267	-41	1226	$14,717	25169.5	$0.58
Denver	12004	-118	1319	-95	1224	$14,694	25169.5	$0.58
Dubai	18103	0	1990	0	1990	$23,875	25169.5	$0.95
ElPaso	13822	-50	1519	-40	1479	$17,744	25169.5	$0.70
Fairbanks	14078	-157	1547	-126	1422	$17,059	25169.5	$0.68
GreatFalls	11509	-40	1265	-32	1232	$14,790	25169.5	$0.59
HoChiMinh	14873	0	1635	0	1635	$19,615	25169.5	$0.78
InternationalFalls	12749	-95	1401	-76	1325	$15,904	25169.5	$0.63
Miami	15460	0	1699	0	1699	$20,384	25169.5	$0.81
NewDelhi	16277	1	1789	1	1790	$21,476	25169.5	$0.85
NewYork	11932	-12	1311	-10	1302	$15,622	25169.5	$0.62
PortAngeles	10436	-1	1147	-1	1146	$13,756	25169.5	$0.55
Rochester	12563	-72	1381	-58	1323	$15,872	25169.5	$0.63
SanDiego	11373	-10	1250	-8	1242	$14,903	25169.5	$0.59
Seattle	11632	-139	1278	-111	1167	$14,004	25169.5	$0.56
Tampa	16769	-1	1843	-1	1842	$22,108	25169.5	$0.88
Tucson	12771	0	1404	0	1404	$16,847	25169.5	$0.67

Large Hotel – These typically use large VAV fans. Again, in all cases, the additional cost of $0.192 per cfm is much less than the projected savings:

	Elec Energy Savings (kWh)	Gas Energy Savings (Therm)	Elec Energy Cost Savings ($)	Gas Energy Cost Savings ($)	Total Energy Cost Savings ($)	Annual Savings X12	Modeled Airflow	$/cfm
Albuquerque	24756	-20	2721	-16	2704	$32,451	40110.4	$0.81
Atlanta	20992	-24	2307	-19	2288	$27,453	40110.4	$0.68
Buffalo	19504	-60	2144	-49	2095	$25,140	40110.4	$0.63
Denver	24984	-45	2746	-36	2710	$32,520	40110.4	$0.81
Dubai	24856	-3	2732	-2	2729	$32,752	40110.4	$0.82
ElPaso	23902	-12	2627	-10	2617	$31,407	40110.4	$0.78
Fairbanks	16880	-72	1855	-58	1797	$21,565	40110.4	$0.54
GreatFalls	21103	-55	2319	-44	2275	$27,300	40110.4	$0.68
HoChiMinh	26707	-10	2935	-8	2927	$35,128	40110.4	$0.88
Honolulu	22710	-3	2496	-3	2493	$29,918	40110.4	$0.75
InternationalFalls	18937	-73	2081	-59	2022	$24,267	40110.4	$0.61
NewDelhi	24433	-8	2685	-7	2679	$32,143	40110.4	$0.80
NewYork	20083	-38	2207	-31	2177	$26,118	40110.4	$0.65
PortAngeles	19082	-24	2097	-19	2078	$24,937	40110.4	$0.62
Rochester	19824	-84	2179	-67	2112	$25,338	40110.4	$0.63
SanDiego	19085	-16	2097	-13	2084	$25,013	40110.4	$0.62
Seattle	19438	-27	2136	-22	2115	$25,375	40110.4	$0.63
Tampa	23725	-9	2607	-7	2600	$31,201	40110.4	$0.78
Tucson	23380	-11	2569	-9	2560	$30,726	40110.4	$0.77

Standalone Retail – These prototypes use a mix of small and large fans. However, the 12-year savings are much higher than the per cfm cost of both sizes.

	Elec Energy Savings (kWh)	Gas Energy Savings (Therm)	Elec Energy Cost Savings ($)	Gas Energy Cost Savings ($)	Total Energy Cost Savings ($)	Annual Savings X12	Modeled Airflow	$/cfm
Albuquerque	7589	-85	834	-68	766	$9,195	23371.2	$0.39
Atlanta	4501	-43	495	-35	460	$5,521	23371.2	$0.24
Buffalo	6972	-152	766	-122	645	$7,736	23371.2	$0.33
Denver	7759	-136	853	-109	744	$8,927	23371.2	$0.38
Dubai	10695	0	1175	0	1175	$14,103	23371.2	$0.60
ElPaso	10139	-66	1114	-53	1061	$12,736	23371.2	$0.54
Fairbanks	7159	-186	787	-149	638	$7,653	23371.2	$0.33
GreatFalls	7475	-171	822	-137	684	$8,210	23371.2	$0.35
HoChiMinh	10356	0	1138	0	1138	$13,657	23371.2	$0.58
InternationalFalls	6591	-140	724	-113	612	$7,341	23371.2	$0.31
Miami	9071	-1	997	-1	996	$11,956	23371.2	$0.51
NewDelhi	9863	-15	1084	-12	1072	$12,863	23371.2	$0.55
NewYork	6897	-121	758	-97	661	$7,927	23371.2	$0.34
PortAngeles	6750	-133	742	-106	635	$7,625	23371.2	$0.33
Rochester	7617	-179	837	-144	693	$8,320	23371.2	$0.36
SanDiego	6986	-11	768	-9	759	$9,109	23371.2	$0.39
Seattle	6975	-114	767	-92	675	$8,100	23371.2	$0.35
Tampa	7270	-12	799	-10	789	$9,472	23371.2	$0.41
Tucson	7817	-10	859	-8	851	$10,216	23371.2	$0.44

Large Office – These prototypes use large VAV fans. In this case, the additional cost of $0.192 per cfm meets the scalar for most climate zones. It does not meet the scalar for Climate Zone 8.

	Elec Energy Sa	Gas Energy Sa	Total Energy U	nergy Savings (	ergy Savings (	nergy Cost Savi	ergy Cost Savi	nergy Cost Savi	Annual Savings X12	Modeled Airflow	$/cfm
Albuquerque	222.89	-9.75	213.14	61963	-92	6810	-74	6736	$80,828	255854.8	$0.32
Atlanta	172.59	-0.7	171.89	47980	-7	5273	-5	5268	$63,212	255854.8	$0.25
Buffalo	152.66	-1.6	151.06	42439	-15	4664	-12	4652	$55,823	255854.8	$0.22
Denver	200.94	-15.33	185.61	55861	-145	6139	-117	6023	$72,271	255854.8	$0.28
Dubai	224.07	-0.08	223.99	62291	-1	6846	-1	6845	$82,143	255854.8	$0.32
ElPaso	231.17	-3.94	227.23	64265	-37	7063	-30	7033	$84,394	255854.8	$0.33
Fairbanks	52.95	-4.04	48.91	14720	-38	1618	-31	1587	$19,044	255854.8	$0.07
GreatFalls	148.99	-7.86	141.13	41419	-75	4552	-60	4492	$53,906	255854.8	$0.21
HoChiMinh	352.43	-0.45	351.98	97976	-4	10768	-3	10764	$129,169	255854.8	$0.50
InternationalFalls	189.47	-1.72	187.75	52673	-16	5789	-13	5776	$69,308	255854.8	$0.27
Miami	334.69	-0.31	334.38	93044	-3	10226	-2	10223	$122,678	255854.8	$0.48
NewDelhi	215.16	-1.05	214.11	59814	-10	6574	-8	6566	$78,788	255854.8	$0.31
NewYork	226.87	-0.49	226.38	63070	-5	6931	-4	6928	$83,132	255854.8	$0.32
PortAngeles	191.2	-16.32	174.88	53154	-155	5842	-124	5717	$68,610	255854.8	$0.27
Rochester	102.91	-0.29	102.62	28609	-3	3144	-2	3142	$37,703	255854.8	$0.15
SanDiego	158.62	-1.12	157.5	44096	-11	4846	-9	4838	$58,052	255854.8	$0.23
Seattle	240.28	-13.24	227.04	66798	-126	7341	-101	7240	$86,885	255854.8	$0.34
Tampa	222.8	-0.17	222.63	61938	-2	6807	-1	6806	$81,669	255854.8	$0.32
Tucson	219.17	-1.47	217.7	60929	-14	6696	-11	6685	$80,219	255854.8	$0.31

[Note to Reviewers: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.]

Addendum bo to 90.1-2019

Modify the standard as follows (I-P and SI Units)

Make the following changes in Section 3.2 - Definitions:

fan electrical input power: the electrical input power in kilowatts required to operate an individual fan or *fan array* at design conditions. It includes the power consumption of motor controllers, if present.

fan nameplate electrical input power: the nominal electrical input power rating stamped on a fan assembly nameplate.

fan system: all the fans that contribute to the movement of air serving *spaces* that pass through a point of a common duct, plenum, or cabinet.

> ***fan system, complex:*** a *fan system* that combines a *single-cabinet fan system* with other supply fans, exhaust fans, or both.
>
> ***fan system, exhaust/relief:*** a *fan system* dedicated to the removal of air from interior spaces to the outdoors.
>
> ***fan system, return:*** a *fan system* dedicated to removing air from the interior where some or all the air is to be recirculated except during economizer operation.
>
> ***fan system, supply-only:*** a *fan system* that provides supply air to interior spaces and does not recirculate the air.

fan system, single-cabinet: a *fan system* where a single fan, single *fan array*, a single set of fans operating in parallel, or fans or *fan arrays* in series and embedded in the same cabinet that both supply air to a space and recirculate the air.

fan system, transfer: a *fan system* that exclusively moves air from one occupied space to another.

fan system airflow: the sum of the airflow of all fans with *fan electrical input power* greater than 1 kW at *fan system design conditions*, excluding the airflow that passes through downstream fans with *fan electrical input power* less than 1 kW.

fan system design conditions: operating conditions that can be expected to occur during normal *system* operation that result in the highest ~~supply~~ airflow rate of ~~to *conditioned spaces* served by~~ the *system*, other than during *air economizer* operation.

***fan system electrical input power*:** the sum of the *fan electrical* input *power* in kilowatts of all fans that are required to operate at *fan system design conditions* ~~to supply air from the heating or cooling source to the conditioned *spaces*, return it to the source, exhaust it to the outdoors, or transfer it to another space~~.

Make the following changes to Section 6.1.1.3 (I-P and SI):

6.1.1.3 Alterations to Heating, Ventilating, Air Conditioning, and Refrigeration in Existing Buildings 6.1.1.3.1

New HVACR *equipment* as a direct replacement of existing HVACR *equipment* shall comply with the following sections as applicable for the *equipment* being replaced:

a. 6.3, "Simplified Approach Option for *HVAC Systems*"
b. 6.4.1, "*Equipment* Efficiencies, Verification, and Labeling Requirements"
c. 6.4.3.1, "Zone *Thermostatic Controls*"
d. 6.4.3.2, "*Set-Point* Overlap Restrictions"
e. 6.4.3.3, "Off-Hour *Controls*" except for Section 6.4.3.3.4, "Zone Isolation"
f. 6.4.3.4, "*Ventilation System Controls*"
g. 6.4.3.7, "Freeze Protection and Snow/Ice Melting *Systems*"
h. 6.4.3.8, "*Ventilation Controls* for High-Occupancy Areas" only for single-zone *equipment*
i. 6.4.3.9, "Heated or Cooled Vestibules"
j. 6.4.5, "*Walk-In Coolers* and *Walk-In Freezers*"
k. 6.5.1.1, "*Air Economizers*" for units located outdoors
l. 6.5.1.3, "Integrated Economizer *Control*"
m. 6.5.1.4, "Economizer Heating *System* Impact"
n. 6.5.3.1.1 "Fan Power Limits"
~~n~~o. 6.5.3.1.3, "Fan *Efficiency*"
~~o~~p. 6.5.3.2.1, "Supply Fan Airflow *Control*"
~~p~~q. 6.5.3.6, "Fractional Horsepower Fan Motors"
~~q~~r. 6.5.4.1, "*Boiler* Turndown"
~~r~~s. 6.5.4.3, "Chiller and *Boiler* Isolation"
~~s~~t. 6.5.5.2, "Fan Speed *Control*"

Make the following changes to the text of Section 6.1.5.3.1 (I-P and SI)

6.5.3 Air System Design and Control

6.5.3.1 Fan System Power and Efficiency

6.5.3.1.1 Fan Power Limits

Each ~~*HVAC*~~ *fan system* that includes at least one fan or *fan array* with *fan electrical input power* greater than 1 kW, *fan system electrical input power* determined per Section 6.5.3.1.1.2 at the *fan system* design airflow shall not exceed the limit as calculated per Section 6.5.3.1.1.1~~*system* having a total *fan system motor nameplate horsepower(kilowatts)* exceeding 5 hp(3.7 kW) at *fan system design conditions* shall not exceed the allowable *fan system motor nameplate horsepower(kilowatts)* (Option 1) or fan *system* bhp(input kW) (Option 2) as shown in Table 6.5.3.1-1. This includes supply fans, return/relief fans, exhaust fans, and fan-powered terminal units associated with *systems* providing heating or cooling capability that operate at *fan system design conditions*. Single-zone *VAV systems* shall comply with the constant-volume fan power limitation~~.

6.5.3.1.1.1 Calculation of the Fan Power Limit

To determine the maximum *fan system electrical input power* allowed for a *fan system*, complete steps 1 through 5:

1. Determine the *fan system's* classification. A *fan system* is considered to be multizone VAV if it meets the following requirements. *Fan systems* that do not meet the requirements shall be classified as other fans:
   a. The *fan system* must serve three or more *HVAC zones* and airflow to each must be individually controlled based on heating, cooling and/or ventilation requirements.
   b. The sum of the minimum airflows for each *HVAC zone* must be 40% or less of the *fan system design conditions*.

Exception~~s~~ to 6.5.3.1.1.1(1)

1. Hospital, vivarium, and laboratory *systems* that use flow *control devices* on exhaust and/or return to maintain *space* pressure relationships necessary for occupant health and safety or environmental *control* ~~may~~shall use the Multi-zone VAV~~variable-volume~~ fan power ~~limitation~~allowances.
2. Individual exhaust fans with motor *nameplate horsepower(kilowatts)* of 1 hp(0.75 kW) or less.

~~**Table 6.5.3.1-1 Fan Power Limitation[a]**~~

	~~Limit~~	~~Constant Volume~~	~~Variable Volume~~
~~Option 1: Fan *system* motor nameplate *hpkW*~~	~~Allowable *motor nameplate hpkW*~~	~~hp*kW* ≤ cfm$_S$L/S$_S$ × 0.00110.0017~~	~~hp*kW* ≤ cfm$_S$L/S$_S$ × 0.00150.0024~~
~~Option 2: Fan *system* bhpinput *kW*~~	~~Allowable fan *system* bhpinput *kW*~~	~~bhp*kW*$_i$ ≤ cfm$_S$L/S$_S$ × 0.000940.0015 + *A*~~	~~bhpkW$_i$ ≤ cfm$_S$L/S$_S$ × 0.00130.0021 + *A*~~

a. ~~where~~
b. ~~cfm$_S$L/S$_S$ = maximum design supply airflow rate to *conditioned spaces* served by the *system* in cubic feet per minutelitres per second~~
c. ~~hpkW = maximum combined motor nameplate horsepowerkilowatts~~
d. ~~*A* =sum of (PD × × cfm$_D$L/s$_D$/413165,000)~~
e. ~~where~~
f. ~~PD=each applicable pressure drop adjustment from Table 6.5.3.1-2 in in. of waterPa~~

g. $cfm_D L/s_D$ = the design airflow through each applicable device from Table 6.5.3.1-2 in cubic feet per minutelitres per second

Table 6.5.3.1-2 Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment
Credits	
Return or exhaust *systems* required by code or accreditation standards to be fully ducted, or *systems* required to maintain air pressure differentials between adjacent rooms.	0.5 in. of water125 Pa (2.15 in. of water535 Pa for laboratory and vivarium *systems*)
Return and/or exhaust airflow *control devices*	0.5 in. of water125 Pa
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at *fan system design condition*
Particulate Filtration Credit: MERV 9 through 12	0.5 in. of water125 Pa
Particulate Filtration Credit: MERV 13 through 15	0.5 in. of water225 Pa
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at *fan system design condition*
Carbon and other gas-phase air cleaners	Clean filter pressure drop at *fan system design condition*
Biosafety cabinet	Pressure drop of device at *fan system design condition*
Energy recovery device, other than coil runaround loop	For each airstream [(2.2550 × *Enthalpy Recovery Ratio*) – 0.5125] in. of waterPa
Coil runaround loop	0.6 in. of water150 Pa for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at *fan system design condition*
Sound attenuation section (fans serving *spaces* with design background noise goals below NC35)	0.15 in. of water38 Pa
Exhaust *system* serving fume hoods	0.35 in. of water85 Pa
Laboratory and vivarium exhaust *systems* in high-rise *buildings*	0.25 in. of water/100 ft60 Pa/30 m of vertical duct exceeding 75 ft25 m
Deductions	
Systems without central cooling device	–0.6 in. of water150 Pa
Systems without central heating device	–0.3 in. of water75 Pa
Systems with central *electric resistance* heat	–0.2 in. of water50 Pa

2. Determine the *fan system* type and choose the appropriate table(s) for the calculation of the fan power allowance.
   a. For *single-cabinet fan systems*, use the the power allowances in both Table 6.5.3.1-1 and Table 6.5.3.1-2.
   b. For *supply-only fan systems*, use the power allowances in Table 6.5.3.1-1.
   c. For *exhaust/relief fan systems*, use the design exhaust or relief airflow and the power allowances in Table 6.5.3.1-2.
   d. For return and *transfer fan systems*, use and the power allowances in Table 6.5.3.1-2.
   e. For *complex fan systems*, separately calculate the fan power allowance for the supply and return/exhaust systems and sum them. For the supply airflow, use supply airflow at the *fan system design conditions*, and the

power allowances in Table 6.5.3.1-1. For the return exhaust airflow, use return/exhaust airflow at the *fan system design conditions*, and the power allowances in Table 6.5.3.1-2.

3. For each *fan system* determine the components included in the *fan system* and sum the fan power allowances from Table 6.5.3.1-1 and Table 6.5.3.1-2 for those components. All *fan systems* shall include the System Base Allowance. If, for a given component, only a portion of the *fan system airflow* passes through the component, calculate the Fan Power Allowance for that component per this equation:

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} X\, FPA_{comp}$$

Where:

FPA_{adj} is the corrected fan power allowance for the component in w/cfm (w/L/s)

Q_{comp} is the airflow through component in cfm (L/s)

Q_{sys} is the *fan system airflow* in cfm (L/s)

FPA_{comp} is the fan power allowance of the component from Table 6.5.3.1-1 and Table 6.5.3.1-2

4. Multiply the *fan system* design airflow by the sum of the fan power allowances for the *fan system*, then divide by 1,000 to convert to *kW*.

$$FPL = \frac{Q_{sys} \cdot FPA_{sum}}{1{,}000}$$

Where:

FPL is the fan power limit in *kW*

Q_{sys} is the *fan system airflow* in cfm (L/s)

FPA_{sum} is the sum of the fan power allowances for the system in W.

1000 is the conversion from W to *kW*

5. For building sites at elevations greater than 3,000 ft (900 m), multiply the fan power limit by the correction factor from Table 6.5.3.1-3.

$$FPL_{alt} = FPL \cdot C_{alt}$$

Where

FPL_{alt} is the adjusted fan power limit in *kW*.

FPL is the fan power limit in *kW* calculated in step 4.

C_{alt} is the altitude correction factor from Table 6.5.3.1-3

6.5.3.1.1.2 Calculation of the Fan System Electrical Input Power

The *fan system electrical input power* is the sum of the *fan electrical input power* of each fan or *fan array* included in the *fan system* other than fans with *fan electrical input power* ≤ 1 *kW*. If variable speed drives are used their *efficiency* losses shall be included. *Fan system input power* shall be calculated with mid-life filter pressure drop, which is the mean of the clean filter pressure drop and design final filter pressure drop. The *fan electrical input power* for each fan or *fan array* shall be determined using one of the following methods. There is no requirement to use the same method for all fans in a *fan system*:

a. Use the default *fan electrical input power* in Table 6.5.3.1-4 for one or more of the fans. This method cannot be used for *complex fan systems*.

b. Use the *fan electrical input power* at *fan system design conditions* provided by the manufacturer of the fan, *fan array*, or *equipment* that includes the fan or *fan array*, calculated per a test procedure included in 10 CFR Part 430, 10 CFR Part 431, ANSI/AMCA Standard 210, AHRI Standard 430 (431), AHRI Standard 440 (441), or ISO 5801.

c. Use the *fan electrical input power* provided by the manufacturer, calculated at *fan system design conditions* per one of the methods listed in Section 5.3 of ANSI/AMCA 208.

d. Use the *fan nameplate electrical input power*.

Add the following new tables to Section 6.5.3.1 (I-P)

Table 6.5.3.1-1 Fan Power Allowances for Supply Fan Systems

	Multi-Zone VAV *Fan System*[1] Airflow (cfm)			**All Other *Fan Systems* Airflow (cfm)**		
Air System Component	**<5,000**	**5,000 to <10,000**	**≥ 10,000**	**<5,000**	**5,000 to <10,000**	**≥ 10,000**
Base allowance for all systems (select 1)						
Supply System Base Allowance	0.413	0.472	0.480	0.243	0.267	0.248
Particle filtration (select all that apply)						
Filter MERV 12 or less	0.094	0.079	0.073	0.097	0.084	0.075
MERV 13 to MERV 16 Filter	0.210	0.177	0.165	0.217	0.185	0.168
HEPA Filter	0.347	0.292	0.277	0.357	0.304	0.278
Heating (select all that apply)						
Hydronic heating coil (central)	0.047	0.050	0.055	0.049	0.053	0.057
Electric heat	0.047	0.040	0.037	0.049	0.042	0.038
Gas heat	0.071	0.060	0.073	0.061	0.063	0.075
Cooling and dehumidification (select all that apply)						
Hydronic/DX cooling coil, or heat pump coil (wet) [Healthcare facilities can select twice]	0.141	0.118	0.110	0.146	0.125	0.112
Fluid economizer coil	0.141	0.118	0.110	0.146	0.125	0.112
Desiccant *system* – solid or liquid	0.164	0.138	0.128	0.170	0.145	0.131
Hot gas reheat coil	0.047	0.040	0.037	0.049	0.042	0.038
Series energy recovery	0.141	0.118	0.110	0.146	0.125	0.112
Evaporative humidifier/cooler in series with a cooling coil. Value shown is allowed w/cfm per 1.0 in. wg. Determine pressure loss (in. wg) at 400 fpm or maximum velocity allowed by the manufacturer, whichever is less, [Calculation required, see note 2]	0.233	0.196	0.184	0.241	0.205	0.186
Energy recovery						

Enthalpy Recovery Ratio ≥ 0.50 and <0.55)	0.141	0.118	0.110	0.146	0.125	0.112
Enthalpy Recovery Ratio ≥ 0.55 and <0.60)	0.166	0.140	0.130	0.172	0.147	0.133
Enthalpy Recovery Ratio ≥ 0.60 and <0.65)	0.191	0.161	0.151	0.198	0.169	0.153
Enthalpy Recovery Ratio ≥ 0.65 and <0.70)	0.217	0.182	0.171	0.224	0.191	0.173
Enthalpy Recovery Ratio ≥ 0.70 and <0.75)	0.242	0.204	0.191	0.250	0.213	0.193
Enthalpy Recovery Ratio ≥ 0.75 and <0.80)	0.267	0.225	0.212	0.276	0.235	0.213
Enthalpy Recovery Ratio ≥ 0.8)	0.292	0.246	0.232	0.301	0.257	0.234
Run-around liquid or refrigerant coils	0.141	0.118	0.110	0.146	0.125	0.112
Gas-phase filtration (select only 1)						
Gas phase filtration required by code or accredited standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 2]	0.233	0.196	0.184	0.241	0.205	0.186
Other						
Economizer return damper	0.049	0.042	0.038	0.049	0.043	0.039
100% *Outdoor air system* meeting the requirements of Note 3.	0.000	0.000	0.000	0.073	0.104	0.112
Low-turndown single-zone VAV *fan systems* meeting the requirements in note 4.	0.000	0.000	0.000	0.073	0.104	0.094
Air blender	0.047	0.040	0.037	0.049	0.042	0.038
Project is an alteration where the duct *system* is not replaced	0.177	0.197	0.183	0.182	0.209	0.187
Sound attenuation section [fans serving spaces with design background noise goals below NC35]	0.035	0.030	0.027	0.036	0.032	0.029
Deduction for systems that feed a terminal unit or fan coil with a fan with electrical input power < 1kW]	-0.500	-0.500	-0.500	-0.100	-0.100	-0.100

1. See section 6.5.3.1.1.1 (1) for requirements a for a Multizone VAV *System*
2. Power allowances require further calculation. Multiply the actual pressure drop of the device or component by the fan power allowance in Table 6.5.3-1.
3. The 100% *outdoor air system* must serve 3 or more *HVAC zones*.
4. A low-turndown single-zone VAV *fan system* must be capable of and configured to reduce airflow to 50 percent of design airflow and use no more than 30% of the design wattage at that airflow. No more than 10 percent of the design load served by the equipment shall have fixed loads.
5. The deduction of 0.500 W/cfm is a default value for multizone VAV *fan systems*. If the terminal unit or fan coil manufacturer can demonstrate that the share of the unit's fan power required to move the *fan system*'s

air is less than 0.500 W/cfm, that value may be used. The w/cfm shall be calculated by dividing the power required to operate the terminal unit's fan at *fan system design conditions* by the airflow of the terminal unit at those conditions.

Table 6.5.3.1-2 Fan Power Allowances for Exhaust, Return, Relief, Transfer Fan Systems

	Multi-Zone VAV *Fan System*[1] airflow (cfm)			**All Other *Fan Systems* Airflow (cfm)**		
Air System Component	**<5,000**	**5,000 to <10,000**	**≥ 10,000**	**<5,000**	**5,000 to <10,000**	**≥ 10,000**
Exhaust System Base Allowance	0.231	0.256	0.248	0.194	0.192	0.200
Particle filtration						
Filter (any MERV value)[2]	0.049	0.042	0.038	0.049	0.043	0.039
Energy recovery						
Enthalpy Recovery Ratio ≥ 0.50 and <0.55)	0.146	0.125	0.112	0.146	0.128	0.114
Enthalpy Recovery Ratio ≥ 0.55 and <0.60)	0.173	0.148	0.133	0.173	0.150	0.135
Enthalpy Recovery Ratio ≥ 0.60 and <0.65)	0.199	0.170	0.153	0.199	0.173	0.155
Enthalpy Recovery Ratio ≥ 0.65 and <0.70)	0.225	0.192	0.173	0.226	0.196	0.176
Enthalpy Recovery Ratio ≥ 0.70 and <0.75)	0.250	0.214	0.193	0.252	0.218	0.196
Enthalpy Recovery Ratio ≥ 0.75 and <0.80)	0.276	0.236	0.213	0.277	0.240	0.216
Enthalpy Recovery Ratio ≥ 0.8)	0.302	0.258	0.234	0.303	0.263	0.236
Run-around liquid or refrigerant coils	0.146	0.125	0.112	0.146	0.128	0.114
Special exhaust and return system requirements (select all that apply)						
Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.122	0.105	0.094	0.122	0.107	0.096
Return and/or exhaust airflow control devices required by code or accreditation standards to maintain pressure relationships between spaces	0.122	0.105	0.094	0.122	0.107	0.096

Laboratory and vivarium exhaust systems in high-rise buildings for vertical duct exceeding 75 ft. Value shown is allowed w/cfm per 0.25 in. wg for each 100 feet exceeding 75 feet. [Calculation required, see note 3]	0.061	0.053	0.047	0.061	0.054	0.048
Biosafety cabinet. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 3]	0.241	0.206	0.186	0.242	0.210	0.188
Exhaust filters, scrubbers, or other exhaust treatment required by code or standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 3]	0.241	0.206	0.186	0.242	0.210	0.188
Other						
Project is an alteration where the duct system is not replaced	0.106	0.119	0.110	0.109	0.126	0.113
Sound attenuation section (fans serving spaces with design background noise goals below NC35}	0.036	0.032	0.029	0.036	0.032	0.029

1. See Section 6.5.3.1.1.1(1) for requirements for a Multi-Zone VAV *System.*
2. Particle filter pressure loss can only be counted once per *fan system*.
3. Power allowances require further calculation. Multiply the actual pressure drop of the device or component by the fan power allowance in Table 6.5.3-2.

Table 6.5.3.1-3: Fan Power Limit Altitude Correction Factor

Altitude (ft)	Correction factor
<3,000	1.000
≥3,000 and <4,000	0.896
≥4,000 and <5,000	0.864
≥5,000 and <6,000	0.832
≥6,000	0.801

Table 6.5.3.1-4: Default values for *Fan Electrical Input Power* Based on *Motor Nameplate Horsepower*

Motor Nameplate Horsepower	Variable-Speed Drive (*kW*)	Without Variable-Speed Drive (*kW*)
<1	0.96	0.89
≥1 and <1.5	1.38	1.29
≥1.5 and <2	1.84	1.72
≥2 and <3	2.73	2.57
≥3 and <5	4.38	4.17
≥5 and <7.5	6.43	6.15
≥7.5 and <10	8.46	8.13
≥10 and <15	12.47	12.03
≥15 and <20	16.55	16.04
≥20 and <25	20.58	19.92
≥25 and <30	24.59	23.77
≥30 and <40	32.74	31.7
≥40 and <50	40.71	39.46
≥50 and <60	48.5	47.1
≥60 and <75	60.45	58.87
≥75 and ≤100	80.4	78.17

1. This table cannot be used for Motor Nameplate Horsepower values greater than 100.
2. This table is to be used only with motors with a service factor ≤1.15. If the service factor is not provided, this table may not be used

Add the following tables to Section 6.5.3.1 (SI)

Table 6.5.3.1-1 Fan Power Allowances for Supply Fan Systems

	Multi-Zone VAV *Fan System*[1] airflow (L/s)			**All Other *Fan Systems* Airflow (L/s)**		
Air System Component	**<2,360**	**2360 to <4720**	**≥ 4,720**	**<2,360**	**2360 to <4720**	**≥ 4,720**
Base allowance for all systems (select 1)						
Supply System Base Allowance for air handler serving floor ≤6 floors away.	0.195	0.223	0.227	0.115	0.126	0.117

Particle filtration (select all that apply)						
Filter MERV 12 or less	0.044	0.037	0.035	0.046	0.039	0.036
MERV 13 to MERV 16 Filter	0.099	0.083	0.078	0.102	0.088	0.079
HEPA Filter	0.164	0.138	0.131	0.168	0.144	0.131
Heating (select all that apply)						
Hydronic heating coil (central)	0.022	0.023	0.026	0.023	0.025	0.027
Electric heat	0.022	0.019	0.017	0.023	0.020	0.018
Gas heat	0.033	0.028	0.035	0.029	0.030	0.036
Cooling and dehumidification (select all that apply)						
Hydronic/DX cooling coil, or heat pump coil (wet) [Healthcare facilities can select twice]	0.066	0.056	0.052	0.069	0.059	0.053
Desiccant system – solid or liquid	0.077	0.065	0.061	0.080	0.068	0.062
Hot gas reheat coil	0.022	0.019	0.017	0.023	0.020	0.018
Series energy recovery	0.066	0.056	0.052	0.069	0.059	0.053
Evaporative humidifier/cooler in series with a cooling coil. Value shown is allowed w/cfm per 1.0 in. wg. Determine pressure loss (in. wg) at 400 fpm or maximum velocity allowed by the manufacturer, whichever is less, [Calculation required, see note 4]	0.110	0.092	0.087	0.114	0.097	0.088
Energy recovery						
Enthalpy Recovery Ratio ≥ 0.50 and <0.55)	0.066	0.056	0.052	0.069	0.059	0.053
Enthalpy Recovery Ratio ≥ 0.55 and <0.60)	0.078	0.066	0.061	0.081	0.069	0.063
Enthalpy Recovery Ratio ≥ 0.60 and <0.65)	0.090	0.076	0.071	0.094	0.080	0.072
Enthalpy Recovery Ratio ≥ 0.65 and <0.70)	0.102	0.086	0.081	0.106	0.090	0.082
Enthalpy Recovery Ratio ≥ 0.70 and <0.75)	0.114	0.096	0.090	0.118	0.101	0.091
Enthalpy Recovery Ratio ≥ 0.75 and <0.80)	0.126	0.106	0.100	0.130	0.111	0.101
Enthalpy Recovery Ratio ≥ 0.8)	0.138	0.116	0.110	0.142	0.121	0.110
Run-around liqud or refrigerant coils	0.066	0.056	0.052	0.069	0.059	0.053
Gas-phase filtration						
Gas phase filtration required by code or accredited standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 3]	0.110	0.092	0.087	0.114	0.097	0.088
Other						
Economizer return damper	0.023	0.020	0.018	0.023	0.020	0.018
100% Outdoor air system meeting the requirements of Note 3.	0.000	0.000	0.000	0.034	0.049	0.053

Low-turndown single-zone VAV *fan systems* meeting the requirements in note 4.	0.000	0.000	0.000	0.034	0.049	0.044
Economizer return damper	0.022	0.019	0.017	0.023	0.020	0.018
Air blender	0.022	0.019	0.017	0.023	0.020	0.018
Project is an alteration where the duct system is not replaced	0.084	0.093	0.086	0.086	0.099	0.088
Sound attenuation section [fans serving spaces with design background noise goals below NC35]	0.017	0.014	0.013	0.017	0.015	0.013
Deduction for systems that feed a terminal unit or fan coil with a fan with electrical input power < 1kW[5]	-0.236	-0.236	-0.236	-0.047	-0.047	-0.047

1. See section 6.5.3.1.1.1 (1) for requirements a for a Multizone VAV *System.*
2. Power allowances require further calculation. Multiply the actual pressure drop of the device or component by the fan power allowance in Table 6.5.3-1.
3. The 100% *outdoor air system* must serve 3 or more *HVAC zones.*
4. A low-turndown single-zone VAV *fan system* must be capable of and configured to reduce airflow to 50 percent of design airflow and use no more than 30% of the design wattage at that airflow. No more than 10 percent of the design load served by the equipment shall have fixed loads.
5. The deduction of 0.236 L/s is a default value for multizone VAV *fan systems*. If the terminal unit or fan coil manufacturer can demonstrate that the share of the unit's fan power required to move the *fan system*'s air is less than 0.236 L/s, that value may be used. The L/s shall be calculated by dividing the power required to operate the terminal unit's fan at *fan system design conditions* by the airflow of the terminal unit at those conditions.

Table 6.5.3.1-2 Fan Power Allowances for Exhaust, Return, Relief, Transfer Fan Systems

	Multi-Zone VAV *Fan System*[1] airflow (L/s)			**All Other *Fan Systems* Airflow (L/s)**		
Air System Component	**<2,360**	**≥2360 to <4720**	**≥ 4,720**	**<2,360**	**2360 to <4720**	**≥ 4,720**
Exhaust System Base Allowance	0.109	0.121	0.117	0.092	0.091	0.094
Particle filtration						
Filter (any MERV value)	0.023	0.020	0.018	0.023	0.020	0.018
Energy recovery						
Enthalpy Recovery Ratio ≥ 0.50 and <0.55)	0.069	0.059	0.053	0.069	0.060	0.054
Enthalpy Recovery Ratio ≥ 0.55 and <0.60)	0.081	0.070	0.063	0.081	0.071	0.064
Enthalpy Recovery Ratio ≥ 0.60 and <0.65)	0.094	0.080	0.072	0.094	0.082	0.073

Enthalpy Recovery Ratio ≥ 0.65 and <0.70)	0.106	0.091	0.082	0.106	0.092	0.083
Enthalpy Recovery Ratio ≥ 0.70 and <0.75)	0.118	0.101	0.091	0.119	0.103	0.092
Enthalpy Recovery Ratio ≥ 0.75 and <0.80)	0.130	0.111	0.101	0.131	0.113	0.102
Enthalpy Recovery Ratio ≥ 0.8)	0.142	0.122	0.110	0.143	0.124	0.111
Run-around liquid or refrigerant coils	0.069	0.059	0.053	0.069	0.060	0.054
Special exhaust and return system requirements (select all that apply)						
Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.057	0.049	0.044	0.057	0.050	0.045
Return and/or exhaust airflow control devices	0.057	0.049	0.044	0.057	0.050	0.045
Laboratory and vivarium exhaust systems in high-rise buildings for vertical duct exceeding 75 ft. Value shown is allowed w/cfm per 0.25 in. wg for each 100 feet exceeding 75 feet. [Calculation required, see note 3]	0.029	0.025	0.022	0.029	0.025	0.023
Biosafety cabinet. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 3]	0.114	0.097	0.088	0.114	0.099	0.089
Exhaust filters, scrubbers, or other exhaust treatment required by code or standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 3]	0.114	0.097	0.088	0.114	0.099	0.089
Other						
Project is an alteration where the duct system is not replaced	0.050	0.056	0.052	0.051	0.059	0.053
Project is an alteration where an adapter curb is required for the new *fan system*	0.017	0.019	0.017	0.017	0.020	0.018
Sound attenuation section (fans serving spaces with design background noise goals below NC35}	0.017	0.015	0.013	0.017	0.015	0.014

1. See Section 6.5.3.1.1.1(1) for requirements for a Multi-Zone VAV *System.*
2. Particle filter pressure loss can only be counted once per *fan system*.
3. Power allowances require further calculation. Multiply the actual pressure drop of the device or component by the fan power allowance in Table 6.5.3-2.

Table 6.5.3.1-3: Fan Power Limit Altitude Correction Factor

Altitude (m)	Correction factor
<900	1.000
≥900 and <1,200	0.896

≥1,200 and <1,500	0.864
≥1,500 and <1,800	0.832
≥1,800	0.801

Table 6.5.3.1-4: Default values for *Fan Electrical Input Power* Based on *Motor Nameplate Horsepower*

Motor Nameplate kW	Variable-Speed Drive (*kW*)	Without Variable-Speed Drive (*kW*)
<0.75	0.96	0.89
≥0.75 and <1.1	1.38	1.29
≥1.1 and <1.5	1.84	1.72
≥1.5 and <2.2	2.73	2.57
≥2.2 and <3.7	4.38	4.17
≥3.7 and <5.5	6.43	6.15
≥5.5 and <7.5	8.46	8.13
≥7.5 and <11	12.47	12.03
≥11 and <15	16.55	16.04
≥15 and <18.5	20.58	19.92
≥18.5 and <22	24.59	23.77
≥22 and <30	32.74	31.7
≥30 and <37	40.71	39.46
≥37 and <45	48.5	47.1
≥45 and <55	60.45	58.87
≥55 and ≤75	80.4	78.17

1. This table cannot be used for *Motor Nameplate Kilowatt* values greater than 75.
2. This table is to be used only with motors with a service factor ≤1.15. If the service factor is not provided, this table may not be used.

Add to Chapter 12 Normative References:

Air Conditioning, Heating and Refrigeration Institute (AHRI)
2311 Wilson Blvd, Arlington, VA 22201

AHRI 430-2014 (I-P)/AHRI 431-2014 (SI) with Addendum 1	Performance Rating of Central Station Air-handling Unit Supply Fans
AHRI 440-2019 (I-P)/AHRI 441-2019 (SI)	Performance Rating of Fan-coil Units

Air Movement and Control Association International (AMCA)
30 West University Drive, Arlington Heights, IL 60004-1806

AMCA 210-2016/ASHRAE 51-2016	Laboratory Methods of Testing for Certified Aerodynamic Performance Rating

International Organization for Standardization (ISO)
1, rue de Varembe, Case postale 56, CH-1211 Geneve 20, Switzerland

ISO 5801-2017	Fans – Performance testing using standardized airways