

DOCKETED

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T24 FPB Examples and Tool v2

Additional submitted attachment is included below.

Fan Power Limit Examples and Tool

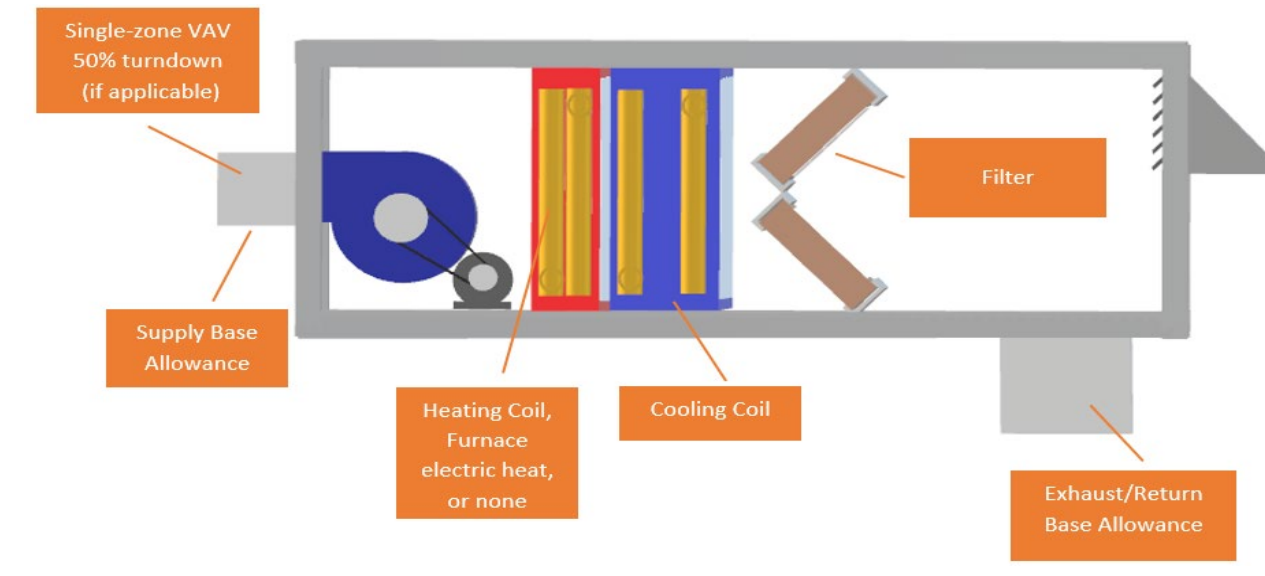
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The purpose of this workbook is to allow stakeholders to work with the proposed fan power limit updates for California Title 24
There are three worksheets that the user can work out of, one for each type of fan system (single fan, supply/return fan, or complex fan systems). In each worksheet the user can enter fan system parameters and see how the resulting power allowance for the proposal compares against the two existing options in 90.1-2019 (i.e., the motor nameplate method and the brake horsepower method). Users only need to modify the orange "input" cells.

Key:
 Input
 Calculation
 Input/Output Value
 Output

System Attributes	
Description	Supply and Return Fan
CAV/SZ VAV/MZ VAV	VAV
Calculation Method	Single-Cabinet Fan System
Supply/Return	
Variable Speed Drive (Yes/No)	Yes
Transmission (Direct/Shaft)	V-Belt
Airflow (cfm)	36000



Airflow	
S2. Filter:	MERV 13-16 Supply 36000
S3. Cooling or Heat Pump Coil:	Yes 36000
S4. Heating Coil:	No 0
S4. Gas Furnace:	Yes 36000
S4. Electric Resistance Heat:	No 0
S5. Economizer Return Damper:	Yes 36000
S7. Hot Gas Reheat Coil:	No 0
S8. 50% Turndown (Single-Zone VAV only):	No 0
EA2. Filter, any MERV value, in the return airstream:	Yes 36000
Fully-ducted return/exhaust where required by code:	Yes 36000
Return and/or exhaust airflow control devices:	No 0

Note: Grey cells contain airflow values that are automatically populated but can be overridden if necessary. Orange cells must be populated by the user.

Results of Fan Power Limit Based on Method:

T24-2019 Methods:

Motor Nameplate Method, max hp:	39.6
Resulting maximum standard motor size, hp:	30.0

Proposed Method:

Brake Horsepower Method	Airflow (cfm)	Pressure Loss (in. wc)	Allowed Brake Horsepower
Base Allowance:	36000	N/A	33.84
MERV 9-12 filter:	0	0.000	0.00
MERV 13 or greater filter:	36000	0.000	0.00
Fully-ducted return/exhaust where required by code:	36000	0.000	0.00
Return and/or exhaust airflow control devices:	0	4.36	0.00
Deduction for no Central Cooling Device:	0	0.000	0.00
Deduction for no Central Heating Device:	0	0.000	0.00
Deduction for Electric Resistance Heat:	0	0.000	0.00
TOTAL:			38.20

Calculation per the proposed Fan Power Limits	Airflow	Allowed w/cfm	Fan Power Allowance (kW)
S1. Supply Base Allowance:	36000	0.236	8.500
S2. Up to MERV 12 Filter:	0	0.000	0.000
S2. MERV 13 to 16 Filter:	36000	0.107	3.850
S2. MERV 13-16 Filter Downstream of Cooling Coil:	0	0.177	0.000
S3. Cooling or Heat Pump Coil:	36000	0.112	4.049
S4. Heating Coil:	0	0.054	0.000
S4. Gas Furnace:	36000	0.072	2.579
S4. Electric Resistance Heat:	0	0.036	0.000
S5. Economizer Return Damper:	36000	0.036	1.297
S7. Hot Gas Reheat Coil:	0	0.036	0.000
S8. 50% Turndown Single-Zone VAV:	0	0.070	0.000
supply side power allowance (kW):			20.275

ER1. Exhaust/Return/Relief Base Allowance:	36000	0.190	6.847
ER2. Filter, any MERV value, in the return airstream:	36000	0.037	1.325
Fully-ducted return/exhaust where required by code:	36000	0.116	4.184
Return and/or exhaust airflow control devices:	0	0.116	0.000
return/exhaust side power allowance (kW):			12.356

Proposed Method Total Supply and Exhaust/Return (kW):	32.632
Estimated allowance per current requirements (kW):	32.659
Reduction from estimated current allowance:	0.1%

Air System Component	Multi-Zone VAV System airflow (cfm)			Constant Volume/Single-zone VAV airflow (cfm)		
	>10,000	>5,000 and ≤10,000	≤5,000	>10,000	>5,000 and ≤10,000	≤5,000
Supply System Base Allowance for air handler serving floor ≤6 floors away:	0.413	0.453	0.395	0.236	0.256	0.232
Filter MERV 12 or less:	0.000	0.000	0.000	0.000	0.000	0.000
Filter MERV 13 to MERV 16 Filter (mid-life):	0.105	0.114	0.135	0.107	0.120	0.139
MERV 13 to MERV 16 final filter located downstream of thermal conditioning:	0.276	0.188	0.224	0.177	0.193	0.231
Hydronic/DX cooling coil, or heat pump coil (wet) (healthcare facilities can self):	0.110	0.118	0.141	0.112	0.125	0.146
Hydronic heating coil (central):	0.052	0.048	0.045	0.054	0.050	0.046
Gas heat:	0.070	0.057	0.068	0.072	0.060	0.058
Electric heat:	0.035	0.038	0.045	0.036	0.040	0.046
Economizer return damper:	0.035	0.038	0.045	0.036	0.040	0.046
Enthalpy Recovery Ratio ≥ 0.65 and <0.65:	0.144	0.155	0.184	0.148	0.163	0.250
Reheat coil for dehumidification:	0.035	0.038	0.045	0.036	0.040	0.046
Low-turndown single-zone VAV fan systems meeting the requirements in note:	0.000	0.000	0.000	0.070	0.100	0.089
Exhaust System Base Allowance:	0.236	0.246	0.221	0.190	0.184	0.180
Filter (any MERV value):	0.036	0.041	0.046	0.037	0.041	0.046
Enthalpy Recovery Ratio ≥ 0.65 and <0.65:	0.148	0.163	0.190	0.148	0.166	0.251
Fully-ducted return/exhaust where required by code:	0.116	0.100	0.089	0.116	0.102	0.091
Return and/or exhaust airflow control devices:	0.116	0.100	0.089	0.116	0.102	0.091

Motor Efficiency Calculations

Fan System 1	n _a				TEFC
	2 POLE	4 POLE	6 POLE	8 POLE	
Quantity of Motors	1				
Motor Nameplate Horsepower	40.0				
Brake HP of 1 fan at design airflow	38.2				
ODP or TEFC	0.924	0.941	0.941	0.917	0.924
Number of Motor Poles	4.0				
Transmission	V-Belt				
Quantity of VFD's	1				
Size of VFD's	40.0				
HP	40	0.98765	0.01695	-0.00380	
Below	50	0.9879	0.0184	-0.0037	
Above	0	0.98765	0.01695	-0.0038	
Linear Interpo					

Belt Efficiency n_b

Motor Shaft Power (HP)	H _{in}	n _b	L _{in}	a	b	c	Motor Efficiency	L _e	VFD & Motor efficiency	Power Consumption
BHP	0.95731585								87.22%	
#REF!	39.90041373	0.941	0.997310343	1.02464	0.00479	-0.019755372	94.1%	1.05996	96.81%	32.66

Fan System 2

Fan System 2	n _a				TEFC
	2 POLE	4 POLE	6 POLE	8 POLE	
Quantity of Motors	1				
Motor Nameplate Horsepower	0.0				
Brake HP of 1 fan at design airflow	0.0				
ODP or TEFC	0.924	0.941	0.941	0.917	0.924
Number of Motor Poles	0.0				
Transmission	#REF!				
Quantity of VFD's	0.0				
Size of VFD's	0.0				
HP	#N/A	#N/A	#N/A	#N/A	
Below	1	0.9803		0.04	-0.0331
Above					
Linear Interpo	#N/A	#N/A	#N/A	#N/A	

Belt Efficiency n_b

Motor Shaft Power (HP)	H _{in}	n _b	L _{in}	a	b	c	Motor Efficiency	L _e	VFD & Motor efficiency	Power Consumption
BHP	#REF!								#REF!	
#REF!	#REF!	FALSE	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

Voltage	Motor Type	Transmission	Lookups		Qty M/F
			M Poles	Qty	
480	GDP	Direct	2	0	1
230	TEFC	V-Belt	4	1	1.5
575		Synchronous Belt	6	2	2
208		Coupling	8	3	3
			4	5	5
			5	7.5	7.5
			6	10	10
			7	15	15
			8	20	20
			9	25	25
			10	30	30
			11	40	40
			12	50	50
			13	60	60
			14	75	75
			15	100	100

VFD, Motor & Transmission Efficiency

n _{trans}	16	125

VFD, Motor & Transmission Efficiency

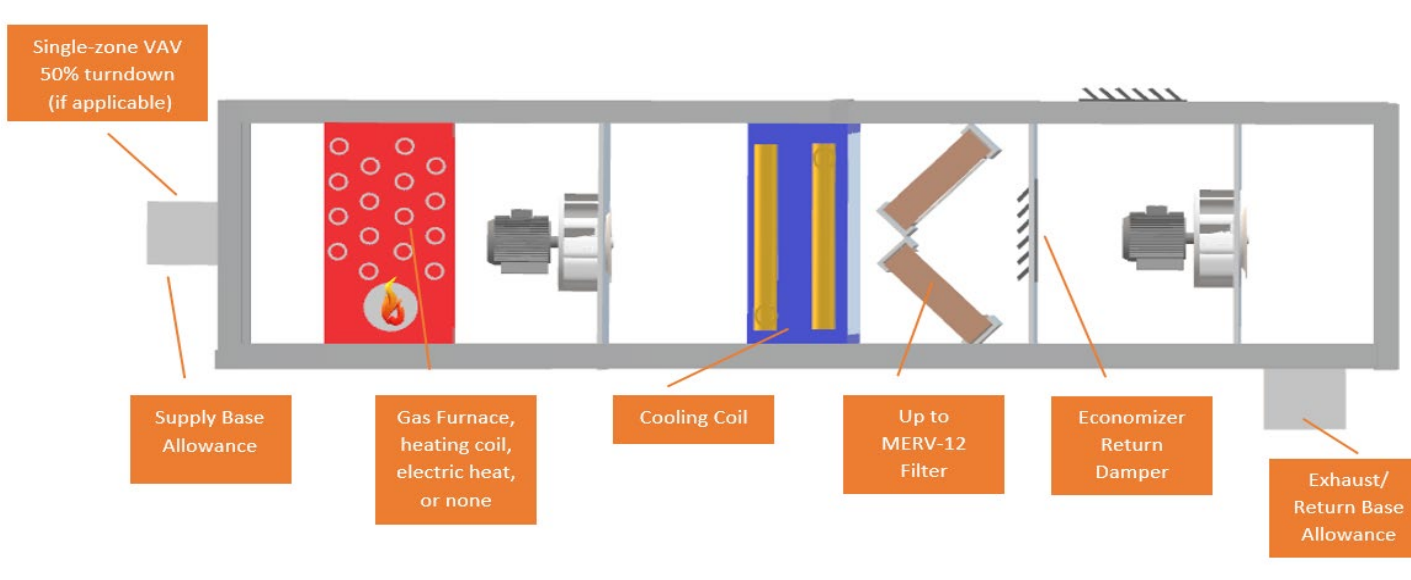
n _{trans}	16	125

Num MP	HP	Basis	System Type	Yes/No	MERV Value
2	HP	Static	CAV	No	MERV 9 or less
4	Current (A)	Total	SZ-VAV	Yes	MERV 9-12
6			MZ-VAV	Yes	MERV 13-16
8				Yes - twice	MERV 13-16 Downstream

System Attributes	Supply and Return Fan
Description:	CAV/SZ VAV/MZ VAV
Calculation Method:	Single-Cabinet Fan System
Variable Speed Drive (Yes/No):	Yes
Transmission (Direct/Shaft):	V-Belt
Airflow (cfm):	7500
Est return/exhaust/relief fan fraction of total bhp:	35.0%

Supply	Return/Exhaust
S2. Filter:	MERV 13-16 7500
S3. Cooling or Heat Pump Coil:	Yes 7500
S4. Heating Coil:	No 0
S4. Gas Furnace:	Yes 7500
S4. Electric Resistance Heat:	No 0
S6 and ER3. Energy Recovery Ventilator:	0 0
S5. Economizer Return Damper:	Yes 7500
S7. Hot Gas Reheat Coil:	No 0
S8. 50% Turndown (Single-Zone VAV only):	Yes 7500
ER2. Filter, any MERV value, in the return airstream:	No 0
Fully-ducted return/exhaust where required by code:	No 0
Return and/or exhaust airflow control device:	No 0

Note: Grey cells contain airflow values that are automatically populated but can be overridden if necessary. Orange cells must be populated by the user.



Results of Fan Power Limit Based on Method:

T24-2019 Methods:

Motor Nameplate Method, max hp:	8.3
Resulting maximum standard motor size, hp:	7.5

Proposed Method:

Brake Horsepower Method	Airflow (cfm)	Additional Pressure Loss (in. wc)	Allowed Brake Horsepower
Base Allowance:	7500	7.05	
MERV 9-12 Filter:	0	0.000	0.00
MERV 13 or greater filter:	7500	0.000	0.00
Energy Recovery Supply Airstream:	0	0.000	0.00
Energy Recovery Exhaust Airstream:	0	0.000	0.00
Fully-ducted return/exhaust where required by code:	0	0.000	0.00
Return and/or exhaust airflow control device:	0	0.000	0.00
Deduction for no Central Cooling Device:	0	0.000	0.00
Deduction for no Central Heating Device:	0	0.000	0.00
Deduction for Electric Resistance Heat:	0	0.000	0.00
TOTAL:			7.05

Supply Fan		Exhaust/Return Relief Fan	
Upsize Motor?	Yes	Yes	Yes
Assumed Motor Nameplate Size:	7.5	5.0	
Brake horsepower:	4.6	2.5	
ODP/TEFC:			
Number of Poles:	4	4	
Wire-to-Shaft efficiency per AMCA 207:	82.06%	77.87%	
Fan electrical power (kW):	4.16	2.36	
Watts per cfm (W):	0.555	0.315	

Calculation per the proposed Fan Power Limits	Airflow	Allowed w/cfm	Fan Power Allowance (kW)
S1. Supply Base Allowance:	7500	0.254	1.915
S2. Up to MERV 12 Filter:	0	0.000	0.000
S2. MERV 13 to 16 Filter:	7500	0.120	0.898
S2. MERV 13-16 Filter Downstream of Cooling Coil:	0	0.197	0.000
S3. Cooling or Heat Pump Coil:	7500	0.125	0.935
S4. Heating Coil:	0	0.059	0.000
S4. Gas Furnace:	7500	0.060	0.453
S4. Electric Resistance Heat:	0	0.040	0.000
S5. Economizer Return Damper:	7500	0.040	0.303
S6. Energy Recovery (ER2-2.5%):	0	0.163	0.000
S7. Hot Gas Reheat Coil:	0	0.040	0.000
S8. 50% Turndown Single-Zone VAV:	7500	0.100	0.751
supply side power allowance (kW):			3.260

ER1. Exhaust/Return/Relief Base Allowance:	7500	0.184	1.379
ER2. Filter, any MERV value, in the return airstream:	0	0.041	0.000
ER3. Energy Recovery (ER2-2.5%):	0	0.166	0.000
Fully-ducted return/exhaust where required by code:	0	0.102	0.000
Return and/or exhaust airflow control device:	0	0.102	0.000
Return/exhaust side power allowance (kW):			1.379

Proposed Method Total Supply and Exhaust/Return (kW):	6.639
Estimated allowance per current requirements (kW):	6.527
Reduction from estimated current allowance:	-1.7%

Air System Component	Multi-Zone VAV System airflow (cfm)			Constant Volume/Single-zone VAV airflow (cfm)		
	>10,000	>5,000 and ≤10,000	≤5,000	>10,000	>5,000 and ≤10,000	≤5,000
Supply System Base Allowance for air handler serving floor ≤6 floors away:	0.413	0.453	0.395	0.236	0.256	0.232
Filter: MERV 12 or less:	0.000	0.000	0.000	0.000	0.000	0.000
Filter: MERV 12 or less (mid-life):	0.105	0.114	0.135	0.107	0.120	0.139
MERV 13 to MERV 16 final filter located downstream of thermal conditioning:	0.276	0.188	0.224	0.277	0.197	0.231
Hydronic/DX cooling coil, or heat pump coil (wet) [healthcare facilities can self]:	0.110	0.118	0.141	0.112	0.125	0.146
Hydronic heating coil (central):	0.052	0.048	0.045	0.054	0.050	0.046
Gas heat:	0.070	0.057	0.068	0.072	0.060	0.058
Electric heat:	0.035	0.038	0.045	0.036	0.040	0.046
Economizer return damper:	0.035	0.038	0.045	0.036	0.040	0.046
Enthalpy Recovery Ratio ≥ 0.65 and < 0.65):	0.144	0.155	0.184	0.146	0.163	0.150
Reheat coil for dehumidification:	0.035	0.038	0.045	0.036	0.040	0.046
Low-turndown single-zone VAV fan systems meeting the requirements in note:	0.000	0.000	0.000	0.070	0.100	0.089
Exhaust System Base Allowance:	0.236	0.246	0.221	0.190	0.184	0.186
Filter (any MERV value):	0.036	0.041	0.046	0.037	0.041	0.046
Enthalpy Recovery Ratio ≥ 0.65 and < 0.65):	0.146	0.163	0.190	0.148	0.166	0.151
Fully-ducted return/exhaust where required by code:	0.116	0.100	0.089	0.116	0.102	0.091
Return and/or exhaust airflow control device:	0.116	0.100	0.089	0.116	0.102	0.091

Motor Efficiency Calculations

Fan System 1	ODP				TEFC	
	2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	2 POLE
Quantity of Motors:	1	1	1	1	1	1
Motor Nameplate Horsepower:	7.5	7.5	7.5	7.5	7.5	7.5
Brake HP of 1 fan at design airflow:	4.6	4.6	4.6	4.6	4.6	4.6
ODP or TEFC:	1.03489	1.03489	1.03489	1.03489	1.03489	1.03489
Number of Motor Poles:	4.0	4.0	4.0	4.0	4.0	4.0
Transmission:	V-Belt	V-Belt	V-Belt	V-Belt	V-Belt	V-Belt
Quantity of VFD's:	1	1	1	1	1	1
Size of VFD's:	7.5	7.5	7.5	7.5	7.5	7.5
Linear Interpol:	0	0	0	0	0	0

Motor Shaft Power (HP)			Motor Efficiency		
BHP	Efficiency η _s	η _{sh}	η _s	η _{sh}	η _{sh}
4.6	0.941362441	4.867943375	0.917	0.917	92.4%

Fan System 2	ODP				TEFC	
	2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	2 POLE
Quantity of Motors:	1	1	1	1	1	1
Motor Nameplate Horsepower:	5.0	5.0	5.0	5.0	5.0	5.0
Brake HP of 1 fan at design airflow:	2.5	2.5	2.5	2.5	2.5	2.5
ODP or TEFC:	1.03641	1.03641	1.03641	1.03641	1.03641	1.03641
Number of Motor Poles:	4.0	4.0	4.0	4.0	4.0	4.0
Transmission:	V-Belt	V-Belt	V-Belt	V-Belt	V-Belt	V-Belt
Quantity of VFD's:	1	1	1	1	1	1
Size of VFD's:	5.0	5.0	5.0	5.0	5.0	5.0
Linear Interpol:	0	0	0	0	0	0

Motor Shaft Power (HP)			Motor Efficiency		
BHP	Efficiency η _s	η _{sh}	η _s	η _{sh}	η _{sh}
2.5	0.929886955	2.653550669	0.895	0.895	89.9%

Voltage	Motor Type	Transmission	Lookups		Qty	M/F
			M Poles	Qty		
480	ODP	Direct	2	0	1	1
230	TEFC	V-Belt	4	1	1.5	2
575		Synchronous Belt	6	2	2	3
208		Coupling	8	3	3	4
				5	5	6
				6	6	7
				7	7	8
				8	8	9
				9	9	10
				10	10	11
				11	11	12
				12	12	13
				13	13	14
				14	14	15
				15	15	16

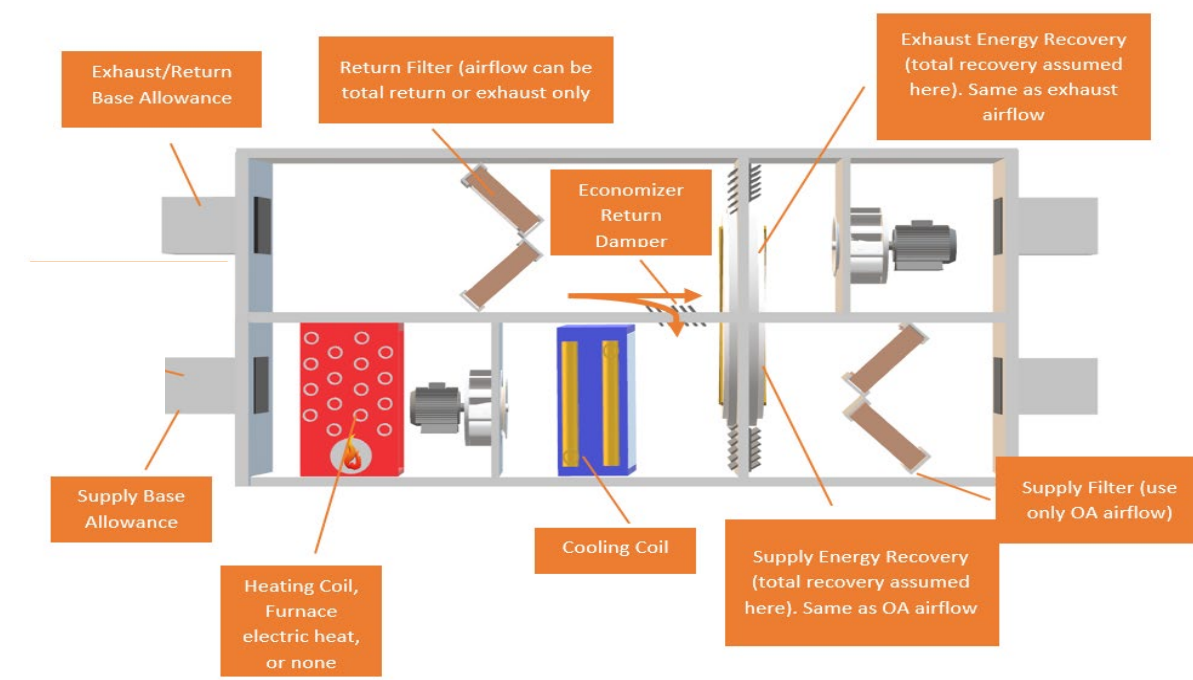
VFD, Motor & Transmission Efficiency η _{total}		VFD & Motor Efficiency	Power Consumption
η _{vfd}	η _{motor}	η _{total}	η _{total}
82.06%	94.38%	87.17%	4.16

VFD, Motor & Transmission Efficiency η _{total}		VFD & Motor Efficiency	Power Consumption
η _{vfd}	η _{motor}	η _{total}	η _{total}
77.87%	95.10%	83.74%	2.36

VFD	current or		FEI Pressure	System	Yes/No	MERV
	Num MP	HP				
2	HP	Static	CAV	No		MERV 9 or less
4	Current (A)	Total	SZ-VAV	Yes		MERV 9-12
6	8		MZ-VAV	Yes		MERV 13-16
				twice		MERV 13-16 Downstream

Key:
 Input
 Calculation
 Handwritten Value
 Output

System Attributes		Supply and Return Fan
Description:	CAV/SZ VAV/MZ VAV	CAV
Calculation Method:	Single-Cabinet Fan System	
Variable Speed Drive (Yes/No):	Yes	Yes
Transmission (Direct/Shaft):	V-Belt	V-Belt
Airflow (cfm):	9000	8000
Est return/exhaust/relief fan fraction of total bhp:	20.0%	



		Supply	Return/Exhaust
S2. Filter:	MERV 13-16	9000	
S3. Cooling or Heat Pump Coil:	Yes	9000	
S4. Heating Coil:	No	0	
S4. Gas Furnace:	Yes	9000	
S4. Electric Resistance Heat:	No	0	
S6 and ER3. Energy Recovery Ventilator:	Yes	3000	2000
S5. Economizer Return Damper:	No	6000	
S7. Hot Gas Reheat Coil:	No	0	
S8. 50% Turndown (Single-Zone VAV only):	No	0	
ER2. Filter, any MERV value, in the return airstream:	No		0
Fully-ducted return/exhaust where required by code:	Yes		8000
Return and/or exhaust airflow control devices:	Yes		8000

Note: Grey cells contain airflow values that are automatically populated but can be overridden if necessary. Orange cells must be populated by the user.

Results of Fan Power Limit Based on Method:

T24-2019 Methods:

Motor Nameplate Method, max hp:	9.9
Resulting maximum standard motor size, hp:	7.5

Proposed Method:

Brake Horsepower Method	Airflow (cfm)	Additional Pressure Loss (in. wc)	Allowed Brake Horsepower
Base Allowance	9000	0.45	
MERV 9-12 Filter:	0	0.000	0.00
MERV 13 or greater filter:	9000	0.000	0.00
Energy Recovery Supply Airstream:	3000	0.148	0.14
Energy Recovery Exhaust Airstream:	2000	0.075	0.42
Fully-ducted return/exhaust where required by code:	8000	0.500	0.97
Return and/or exhaust airflow control devices:	8000	0.408	0.97
Deduction for no Central Cooling Device:	0	0.000	0.00
Deduction for no Central Heating Device:	0	0.000	0.00
Deduction for Electric Resistance Heat:	0	0.000	0.00
TOTAL:			11.46

		Supply Fan	Exhaust/Relief Fan
Upsize Motor?	Yes	Yes	
Assumed Motor Nameplate Size:	15.0	5.0	
Brake horsepower:	9.2	2.3	
ODP/TEFC:	4	4	
Wire-to-Shaft efficiency per AMCA 207:	84.52%	77.38%	
Fan electrical power (kW):	8.09	2.21	
Watts per cfm (W):	0.898	0.276	

Calculation per the proposed Fan Power Limits	Airflow (cfm)	Allowed w/cfm	Fan Power Allowance (kW)
S1. Supply Base Allowance:	9000	0.254	2.303
S2. Up to MERV 12 Filter:	0	0.000	0.000
S2. MERV 13 to 16 Filter:	9000	0.120	1.078
S2. MERV 13-16 Filter Downstream of Cooling Coil:	0	0.197	0.000
S3. Cooling or Heat Pump Coil:	9000	0.125	1.122
S4. Heating Coil:	0	0.050	0.000
S4. Gas Furnace:	9000	0.000	0.544
S4. Electric Resistance Heat:	0	0.040	0.000
S5. Economizer Return Damper:	6000	0.040	0.243
S6. Energy Recovery (ER2 & ER3):	2000	0.163	0.488
S7. Hot Gas Reheat Coil:	0	0.040	0.000
S8. 50% Turndown Single-Zone VAV:	0	0.100	0.000
supply side power allowance (kW):			5.778

	Airflow (cfm)	Allowed w/cfm	Fan Power Allowance (kW)
ER1. Exhaust/Return/Relief Base Allowance:	8000	0.184	1.471
ER2. Filter, any MERV value, in the return airstream:	0	0.041	0.000
ER3. Energy Recovery (ER2 & ER3):	2000	0.166	0.313
Fully-ducted return/exhaust where required by code:	8000	0.102	0.820
Return and/or exhaust airflow control devices:	8000	0.102	0.820
return/exhaust side power allowance (kW):			3.442

Proposed Method Total Supply and Exhaust/Return (kW):	9.220
Estimated allowance per current requirements (kW):	10.294
Reduction from estimated current allowance:	10.4%

Air System Component	Multi-Zone VAV System airflow (cfm)			Constant Volume/Single-zone VAV airflow (cfm)		
	>10,000	>5,000 and ≤10,000	≤5,000	>10,000	>5,000 and ≤10,000	≤5,000
Supply System Base Allowance for air handler serving floor ≤6 floors away:	0.413	0.453	0.395	0.236	0.256	0.232
Filter: MERV 12 or less:	0.000	0.000	0.000	0.000	0.000	0.000
Filter: MERV 13 to 16 (mid-life):	0.105	0.114	0.135	0.107	0.120	0.139
Filter: MERV 13 to 16 (end-of-life):	0.276	0.188	0.224	0.177	0.197	0.231
Hydronic/DX cooling coil, or heat pump coil (wet) [healthcare facilities can set]:	0.110	0.118	0.141	0.112	0.125	0.146
Hydronic heating coil (central):	0.052	0.048	0.045	0.054	0.050	0.046
Gas heat:	0.070	0.057	0.068	0.071	0.060	0.058
Electric heat:	0.035	0.038	0.045	0.036	0.040	0.046
Economizer return damper:	0.035	0.038	0.045	0.036	0.040	0.046
Enthalpy Recovery Ratio ≥ 0.65 and <0.65:	0.144	0.155	0.184	0.146	0.163	0.190
Reheat coil for dehumidification:	0.035	0.038	0.045	0.036	0.040	0.046
Low-turndown single-zone VAV fan systems meeting the requirements in note:	0.000	0.000	0.000	0.070	0.100	0.089
Exhaust System Base Allowance:	0.236	0.246	0.221	0.190	0.184	0.186
Filter (any MERV value):	0.036	0.041	0.021	0.037	0.041	0.046
Enthalpy Recovery Ratio ≥ 0.65 and <0.65:	0.146	0.163	0.190	0.148	0.166	0.211
Fully-ducted return/exhaust where required by code:	0.116	0.100	0.089	0.116	0.102	0.091
Return and/or exhaust airflow control devices:	0.116	0.100	0.089	0.116	0.102	0.091

Motor Efficiency Calculations

		η_{in}				TEFC																																																																																																																																																																																												
Fan System 1		2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	4 POLE	6 POLE	8 POLE																																																																																																																																																																																									
Quantity of Motors	1	0.902	0.93	0.917	0.902	0.91																																																																																																																																																																																												
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Voltage	Motor Type	Transmission	M Poles	Qty	Qty M/F	VFD		FEI Pressure Basis	System Type	Yes/No	MERV Value
						current or	HP				
480	ODP	Direct	2	0	1			Static	CAV	No	MERV 9 or less
230	TEFC	Synchronous Belt	4	1	1.5			Static	SZ-VAV	Yes	MERV 9-12
575	TEFC	Coupling	6	2	2			Static	MZ-VAV	Yes	MERV 13-16
208	TEFC	Coupling	8	3	3			Static	MZ-VAV	Yes	MERV 13-16

VFD, Motor & Transmission Efficiency η_{total}

VFD, Motor & Transmission Efficiency η_{total}

Table A1. EPCA Nominal Motor Efficiency (60 Hz motors)									Table B1. Polyphase Induction Motor Performance Constants (hp rated motors with VFD)						C1. VFD Performance Constants (hp capacity)						Table D1. Polyphase Induction Motor Performance Constants (hp rated motors DOL)							
ODP				TEFC					HP	2 POLE		4 POLE		6 & 8 POLE		HP	Index	HP	d	e	f	HP	2 POLE		4 POLE		6 & 8 POLE	
2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	4 POLE	6 POLE	8 POLE	a		b	a	b	a	b	a								b	a	b	a	b	a
1	77.0	83.5	82.5	75.5	77.0	85.5	82.5	72.0	1	1.02906	0.01701	1.03744	0.03337	1.09059	0.06457	1	0	1	0.98030	0.04000	-0.01310	1	1.13460	0.08674	1.12541	0.09132	1.16873	0.11466
1.5	84.0	86.5	86.5	77.0	84.0	86.5	87.5	75.5	1.5	1.02998	0.01610	1.03812	0.03120	1.08484	0.05903	1.5	1	1.5	0.97995	0.03855	-0.01180	1.5	1.12932	0.08114	1.12067	0.08492	1.15895	0.10606
2	85.5	86.5	87.5	86.5	85.5	86.5	88.5	81.5	2	1.03090	0.01520	1.03880	0.02902	1.07910	0.05349	2	1.5	2	0.97960	0.03710	-0.01050	2	1.12405	0.07555	1.11592	0.07851	1.14917	0.09747
3	85.5	86.9	88.5	87.5	86.5	89.5	89.5	82.5	3	1.03273	0.01338	1.04016	0.02467	1.06760	0.04240	3	2	3	0.97890	0.03420	-0.00790	3	1.11350	0.06436	1.10643	0.06571	1.12962	0.08027
5	86.5	89.5	89.5	88.5	88.5	89.5	89.5	84.0	5	1.03641	0.00975	1.04288	0.01596	1.04461	0.02024	5	3	5	0.97750	0.02840	-0.00270	5	1.09241	0.04197	1.08745	0.04009	1.09051	0.04588
7.5	88.5	91.0	90.2	89.5	89.5	91.7	91.0	84.0	7.5	1.03489	0.00892	1.04077	0.01446	1.04243	0.01798	7.5	5	7.5	0.97810	0.02530	-0.00040	7.5	1.08883	0.03990	1.08340	0.03745	1.08579	0.04217
10	89.5	91.7	91.7	90.2	90.2	91.7	91.0	87.5	10	1.03338	0.00808	1.03866	0.01296	1.04025	0.01572	10	7.5	10	0.97870	0.02220	0.00190	10	1.08526	0.03783	1.07936	0.03481	1.08107	0.03846
15	90.2	93.0	91.7	90.2	91.0	92.4	91.7	87.5	15	1.03035	0.00641	1.03443	0.00996	1.03588	0.01121	15	10	15	0.98185	0.01985	0.00070	15	1.07811	0.03368	1.07127	0.02953	1.07163	0.03104
20	91.0	93.0	92.4	91.0	91.0	93.0	91.7	88.5	20	1.02732	0.00474	1.03021	0.00696	1.03152	0.00670	20	15	20	0.98500	0.01750	-0.00050	20	1.07096	0.02953	1.06318	0.02425	1.06218	0.02362
25	91.7	93.6	93.0	91.0	91.7	93.6	93.0	88.5	25	1.02654	0.00476	1.02882	0.00642	1.02977	0.00622	25	20	25	0.98620	0.01650	-0.00320	25	1.06949	0.02923	1.06033	0.02291	1.05966	0.02257
30	91.7	94.1	93.6	91.7	91.7	93.6	93.0	90.2	30	1.02575	0.00478	1.02742	0.00588	1.02803	0.00575	30	25	30	0.98740	0.01550	-0.00590	30	1.06802	0.02892	1.05749	0.02157	1.05713	0.02152
40	92.4	94.1	94.1	91.7	92.4	94.1	94.1	90.2	40	1.02418	0.00481	1.02464	0.00479	1.02454	0.00480	40	30	40	0.98765	0.01695	-0.00380	40	1.06508	0.02831	1.05180	0.01889	1.05208	0.01942
50	93.0	94.5	94.1	92.4	93.0	94.5	94.1	91.0	50	1.02261	0.00485	1.02185	0.00370	1.02106	0.00384	50	40	50	0.98790	0.01840	-0.00170	50	1.06214	0.02769	1.04612	0.01621	1.04703	0.01732
60	93.6	95.0	94.5	93.0	93.6	95.0	94.5	91.0	60	1.02226	0.00449	1.02100	0.00350	1.02057	0.00399	60	50	60	0.97190	0.01450	0.01180	60	1.05946	0.02585	1.04436	0.01556	1.04553	0.01691
75	93.6	95.0	94.5	94.1	93.6	95.4	94.5	92.4	75	1.02174	0.00395	1.01972	0.00320	1.01985	0.00420	75	60	75	0.99190	0.01790	-0.00130	75	1.05544	0.02309	1.04172	0.01459	1.04328	0.01631
100	93.6	95.4	95.0	94.1	94.1	95.4	95.0	92.4	100	1.02087	0.00306	1.01758	0.00269	1.01864	0.00455	100	75	100	0.98240	0.01260	0.00140	100	1.04874	0.01849	1.03732	0.01298	1.03954	0.01530
125	94.1	95.4	95.0	94.1	95.0	95.4	95.0	93.0	125	1.01997	0.00299	1.01725	0.00286	1.01956	0.00459	125	100	125	0.98293	0.01190	-0.00010	125	1.04713	0.01813	1.03731	0.01332	1.03948	0.01463
150	94.1	95.8	95.4	94.1	95.0	95.8	95.8	93.0	150	1.01907	0.00293	1.01692	0.00303	1.02047	0.00462	150	125	150	0.98345	0.01120	-0.00160	150	1.04553	0.01778	1.03729	0.01365	1.03942	0.01396
200	95.0	95.8	95.4	94.1	95.4	96.2	95.8	93.6	200	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468	200	150	200	0.98450	0.00980	-0.00460	200	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
250	95.0	95.8	95.4	95.0	95.8	96.2	95.8	94.1	250	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468	250	200	250	0.98450	0.00980	-0.00460	250	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
300	95.4	95.8			95.8	96.2			300	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468	300	250	300	0.98450	0.00980	-0.00460	300	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
350	95.4	95.8			95.8	96.2			350	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468	350	300	350	0.98450	0.00980	-0.00460	350	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
400	95.8	95.8			95.8	96.2			400	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468	400	350	400	0.98450	0.00980	-0.00460	400	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
450	95.8	96.2			95.8	96.2			450	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468	450	400	450	0.98450	0.00980	-0.00460	450	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
500	95.8	96.2			95.8	96.2			500	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468	500	450	500	0.98450	0.00980	-0.00460	500	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262