DOCKETED

Docket Number:	17-AAER-06
Project Title:	Commercial and Industrial Fans & Blowers
TN #:	221209
Document Title:	HARRY M GRAVES Comments FAN EFFICIENCY INDEX A FALSE METRIC
Description:	N/A
Filer:	System
Organization:	HARRY M GRAVES
Submitter Role:	Public
Submission Date:	9/18/2017 2:44:52 PM
Docketed Date:	9/18/2017

Comment Received From: HARRY M GRAVES
Submitted On: 9/18/2017
Docket Number: 17-AAER-06

FAN EFFICIENCY INDEX A FALSE METRIC

PLEASE NOTE THE NODA 3 SPREADSHEET CAN BE ENLARGED FOR PROPER VIEWING.

Additional submitted attachment is included below.

FEI or Fan Energy Index is a false metric. It does not fairly represent the true energy usage by all fans because it uses two different calculations for FEI. One calculation uses static pressure and velocity pressure in the numerator and the other calculation uses only static pressure in the numerator.

All fans develop both static pressure and velocity pressure and their sum is called total pressure. All fans develop static pressure due to the resistance of air flow caused by the fan's surroundings whether it is duct work, a hood, a shutter or the design of the building. Velocity pressure is due to the movement of air. The greater the air velocity the greater the velocity pressure. The goal here is to prove for an equal value of CFM/Watt wall fans and power roof ventilators are penalized unfairly by excluding their velocity pressure component in the calculation of FEI. In fact, FEI actually discriminates against all low pressure high volume flow fans. These wall fans and PRVs fans would easily pass the efficiency level of EL3 if they used total pressure instead of just static pressure in the calculation of FEI.

Some argue that wall fans and PRVs waste the velocity pressure because the air is not pushed down a pipe or duct and therefore velocity pressure should not be included in the calculation of FEI for non ducted fans. This is false because non ducted fans pull the air throughout the building and this air velocity or wind component is exhausted to the outside of the building. Some would argue that it is difficult to test non ducted fans for velocity pressure, however, it can easily be calculated using the Fan Laws.

In agricultural applications this air velocity is used in all Tunnel ventilated housing for poultry, greenhouse, and dairy installations. Currently most poultry houses require a minimum of 600 feet per minute of air velocity. It has been proven that cows provide 10 percent more milk when they have fans blowing on them. In most factories waste heat needs to be removed from the building and fresh air supplied. Paint shops use power roof ventilators to filter the air exhausted from the paint booth. In restaurants power roof ventilators are used to extract heat from the kitchen and filter the air supplied.

Ducted fans tend to push the air down a pipe which some believe is the only good use of velocity pressure. This is the invalid reason for the two different calculations of FEI for ducted and non ducted fans. Ducted and non ducted fans cannot be fairly evaluated with this single metric. The real travesty is shown below where for the same CFM/Watt a ducted fan gets a passing FEI value and a wall fan or power roof ventilator does not.

Lines 18-29 depict the results for wall fans with the same CFM, BHP, SP and TP by calculating the FEI as a ducted fan and then as a non ducted fan. Line 18 shows a wall fan performance calculated as a ducted fan with total pressure and then line 19 shows the same performance but calculated using only static pressure. Since velocity pressure is only used in the ducted fan equation as a numerator the FEI result is much higher, FEI of 1.42 vs. 1.08 for the same CFM/watt. This is a difference of .34 FEI. The ducted fan is suppose to be 23.94 percent more efficient than the wall fan. How untrue. Note at EL3 the target efficiency used was a .66 for a ducted fan and .62 for a non ducted fan thus if we really had a universal metric like FEI then for the same CFM/watt the target efficiency for the non ducted fan would have to be at 50.20 percent not 62 percent. So we really have 2 calculations that create two different FEI values.

One is artificially enhanced with velocity pressure plus static pressure and the non ducted fan only uses static pressure.

Up blast power roof ventilators, JDC36P PRV, on lines 20 and 21 show similar results with FEI ducted 1.31 vs. non ducted 1.04 for the same CFM/watt. The ducted fan is 20.61 percent more efficient? No it is not. Lines 22 and 23 show a low profile hooded exhaust, PDC36P PRV at 3 hp failing both categories due to hood losses and proximity of roof: .87 FEI ducted fan vs. .78 non ducted FEI.

Lines 24 and 25 show same low profile fan, PDC36N, with a smaller 2 HP motor with FEI of 1.03 vs. .97 and again the ducted fan passes and the non ducted fan fails. Lines 26 and 27 depict a hooded exhaust PRV, PEDC36P, ducted 1.16 vs. non ducted .95 FEI but both fans use the same CFM/watt. This means for the same energy consumption the ducted fan passes and the PRV does not and supposedly the ducted fan is 18.11 percent more efficient. Not at all.

Lines 28 and 29 show a hooded supply fan, PSDC36P, 1.13 ducted fan vs. .93 non ducted fan FEI. Where is the 21.51 percent savings in electricity?

Lets look at some larger wall fans on lines 30 and 31. The CBC54Q, 5HP 1.39 FEI as a ducted fan vs. non ducted .92 FEI. Where is the 33.81 percent savings in energy?

Lines 32 and 33 show another wall fan, CBC54R, calculated as a ducted fan 1.18 vs. non ducted fan .82 FEI. Where is the 30.51 percent savings in energy?

CBC 54S, 10HP, FEI 1.17 ducted vs. FEI .72 non ducted. A difference of .45 FEI but using the same amount of energy.

Lines 36 and 37 large hooded exhaust ventilators, PEDC54Q8, barely passes 1.00ducted and .78 non ducted. The next two are both losers PEDC54R8, .98 ducted and .75 non ducted and PEDC54S11, .86 ducted and .62 non ducted.

Up blast power roof ventilators, JBH48P, 1.51 ducted and 1.22 non ducted a difference of .29. JBH48Q, 5 HP, 1.32 ducted fan and .93 non ducted fan . Our JBC 84S, a 10 hp Up Blast PRV, on line 46 and 47 passes ducted 1.54 and non ducted at 1.19 FEI but a difference of .35 FEI for the same performance.

Obviously there is a pattern to all of these calculations. A ducted fan gets to use both static pressure and velocity pressure and a wall fan or PRV can only use static pressure. The real question to ask is why? Could it be that the centrifugal blower market is much larger in sales volume and profit margin than the wall fan and PRV market. Could it be that the vested interests on the ASRAC committee were more interested in protecting their more profitable ducted axial and centrifugal fan products at the expense of the small wall fan and small PRV manufacturers. Why did the ASRAC committee chose to agree to arbitrarily reduce total fan selections by 25 percent based on prior DOE negotiations with the pump industry. Why would it not be logical for each category of fan to lose 25 percent rather than the wall fans losing 22 percent and PRV sectors axial 55 percent and centrifugal PRVs losing 35 percent of their selections based on this false FEI metric instead of using a CFM/watt metric. Yet the ducted centrifugal fans losing only 4 percent for airfoil blades and only 9 percent for backward inclined bladed fans. The ducted tube axials at 19 percent and the ducted vane axial fans at 10 percent.

Why is AMCA so opposed to the Bess Labs metric of CFM/ Watt? At Bess Labs the fans are real world tested with shutters, guards, and cones just like they would be used in a farmer's barn or poultry house. AMCA lost the agricultural markets over thirty years ago. Bess Labs is the worldwide authority on agricultural fans. They have tested over 1900 fans and they are listed on Bess Labs website. Why is there such insistence within AMCA on this false FEI metric to be the only metric of fan electrical efficiency? Why can AMCA not coexist with Bess Labs?

Key

Primary Data Collection Fields (Inputs marked with * do not affect the calculations)

Calculation - DO NOT ENTER DATA

Press [+] above cell BJ1 to review equations

Values of η_{target} at each Efficiency Level (EL) Considered (DUCTED FANS)

EL1	EL2	EL3	EL4	EL5	EL6
62%	64%	66%	68%	70%	72%

Values of η_{target} at each Efficiency Level (EL) Considered (UNDUCTED FANS)

EL1	EL2	EL3	EL4	EL5	EL6
58%	60%	62%	64%	66%	68%

Flow and Pressure Constants (for all ELs)

Q_0	P_0
250	0.4

DUCTED ONLY | UNDUCTED ONLY

INDIVIDUAL FAN INPUT INFORMATION

	Fan Description				Transmission	Design Point				FAN	Default Transmission	Default Motor			FEP
	Brand *	Model Name/ Number *	Fan Equipment Class	Ducted / Unducted	Direct Drive?	Design Airflow (cfm)	Design Total Pressure (in. wg) [Ducted Only]	Design Static Pressure (in. wg) [Unducted Only]	Shaft Input Power, BHP @ Design Point (BHP)	BHP @ Design Point	Transmission Efficiency at Design Point	Motor HP	Full Load Losses	Losses at Design Point (hp)	FEP_fan (kW)
18	C	CDC36P	Axial Cyclindrical Housed	Ducted	Yes	17,409	0.709		3.440	3.44	100%	5	0.59	0.46	2.91
19	D	CDC36P	PRV	Unducted	Yes	17,409		0.375	3.440	3.44	100%	5	0.59	0.46	2.91
20	E	JDC36P	Axial Cyclindrical Housed	Ducted	Yes	16,182	0.660		3.340	3.34	100%	5	0.59	0.45	2.83
21	F	JDC36P	PRV	Unducted	Yes	16,182		0.375	3.340	3.34	100%	5	0.59	0.45	2.83
22	G	PDC36P11	Axial Cyclindrical Housed	Ducted	Yes	12,147	0.535		3.440	3.44	100%	5	0.59	0.46	2.91
23	H	PDC36P11	PRV	Unducted	Yes	12,147		0.375	3.440	3.44	100%	5	0.59	0.46	2.91
24	I	PDC36N11	Axial Cyclindrical Housed	Ducted	Yes	10,078	0.486		2.280	2.28	100%	3	0.35	0.29	1.92
25	J	PDC36N11	PRV	Unducted	Yes	10,078		0.375	2.280	2.28	100%	3	0.35	0.29	1.92
26	K	PEDC36	Axial Cyclindrical Housed	Ducted	Yes	15,024	0.621		3.410	3.41	100%	5	0.59	0.46	2.89
27	l	PEDC36	PRV	Unducted	Yes	15,024		0.375	3.410	3.41	100%	5	0.59	0.46	2.89
28	M	PSDC36	Axial Cyclindrical Housed	Ducted	Yes	14,798	0.613		3.430	3.43	100%	5	0.59	0.46	2.90
29	N	PSDC36	PRV	Unducted	Yes	14,798		0.375	3.430	3.43	100%	5	0.59	0.46	2.90
30	O	CBC54Q	Axial Cyclindrical Housed	Ducted	No	38,628	0.47		5.65	5.65	94%	7.5	0.74	0.64	4.94
31	P	CBC54Q	Panel	Unducted	No	38,628		0.125	5.65	5.65	94%	7.5	0.74	0.64	4.94
32	Q	CBC54R	Axial Cyclindrical Housed	Ducted	No	40,954	0.614		8.40	8.40	95%	15	1.23	0.90	7.28
33	R	CBC54R	Panel	Unducted	No	40,954		0.250	8.40	8.40	95%	15	1.23	0.90	7.28
34	S	CBC54S	Axial Cyclindrical Housed	Ducted	No	47,318	0.75		11.11	11.11	95%	15	1.23	1.04	9.50
35	T	CBC54S	Panel	Unducted	No	47,318		0.250	11.11	11.11	95%	15	1.23	1.04	9.50
36	D1	PEDC54Q8	Axial Cyclindrical Housed	Ducted	Yes	29,869	0.33		5.56	5.56	100%	7.5	0.74	0.61	4.60
37	E1	PEDC54Q8	PRV	Unducted	Yes	29,869		0.125	5.56	5.56	100%	7.5	0.74	0.61	4.60
38	F1	PEDC54R8	Axial Cyclindrical Housed	Ducted	Yes	35,211	0.53		8.51	8.51	100%	15	1.23	0.88	7.01
39	G1	PEDC54R8	PRV	Unducted	Yes	35,211		0.250	8.51	8.51	100%	15	1.23	0.88	7.01
40	H1	PEDC54S11	Axial Cyclindrical Housed	Ducted	Yes	38,047	0.57		11.03	11.03	100%	15	1.23	1.01	8.98
41	I1	PEDC54S11	PRV	Unducted	Yes	38,047		0.250	11.03	11.03	100%	15	1.23	1.01	8.98
42	J1	JBH48P	Axial Cyclindrical Housed	DUCTED	No	24,944	0.47		3.36	3.36	94%	5	0.59	0.47	3.03
43	K1	JBH48P	PRV	Unducted	No	24,944		0.250	3.36	3.36	94%	5	0.59	0.47	3.03
44	L1	JBH48Q	Axial Cyclindrical Housed	Ducted	No	31,306	0.60		5.61	5.61	94%	7.5	0.74	0.63	4.91
45	M1	JBH48Q	PRV	Unducted	No	31,306		0.250	5.61	5.61	94%	7.5	0.74	0.63	4.91
46	N1	JBC84S	Axial Cyclindrical Housed	Ducted	No	82,329	0.52		11.42	11.42	95%	15	1.23	1.06	9.75
47	Q1	JBC84S	PRV	Unducted	No	82,329		0.250	11.42	11.42	95%	15	1.23	1.06	9.75
48	R1	JBC84S	PRV	Unducted	No	88,702		0.125	11.42	11.42	95%	15	1.23	1.06	9.75
49	S1			Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
50	T1	GREEN48	Panel	Unducted	No	40,000		0.130	6.91	6.91	95%	10	0.91	0.74	6.00
51	U1	GREEN 48	Axial Cyclindrical Housed	Ducted	No	40,000	0.72		6.91	6.91	95%	10	0.91	0.74	6.00
52	V1	GREEN54	Panel	Unducted	No	40,000		0.130	5.81	5.81	94%	7.5	0.74	0.65	5.08
53	W1	GREEN 54	Axial Cyclindrical Housed	Ducted	No	40,000	0.49		5.81	5.81	94%	7.5	0.74	0.65	5.08
54	X1	GREEN60	Panel	Unducted	No	40,000		0.130	3.93	3.93	94%	5	0.59	0.52	3.51
55	Y1	GREEN60	Axial Cyclindrical Housed	Ducted	No	40,000	0.36		3.93	3.93	94%	5	0.59	0.52	3.51
56	Z1	GREEN72	Panel	Unducted	No	40,000		0.130	2.63	2.63	93%	5	0.59	0.42	2.42
57	A2	GREEN72	Axial Cyclindrical Housed	Ducted	No	40,000	0.25		2.63	2.63	93%	5	0.59	0.42	2.42
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A
				Ducted						0.00	100%	#N/A	#N/A	#N/A	#N/A

	Minimally Compliant Fan at Design Point, EL1						Minimally Compliant Fan at Design Point, EL2					
	FAN	Default Transmission	Default Motor			FEP	FAN	Default Transmission	Default Motor			FEP
	Max BHP @ Design Point	Transmission Efficiency at Design Point	Motor HP	Full Load Losses	Losses at Design Point (hp)	FEP_EL1 (kW)	Max BHP @ Design Point	Transmission Efficiency at Design Point	Motor HP	Full Load Losses	Losses at Design Point (hp)	FEP_EL2 (kW)
18	4.98	94%	5	0.59	0.59	4.4	4.82	94%	5	0.59	0.59	4.3
19	3.72	94%	5	0.59	0.50	3.3	3.60	94%	5	0.59	0.49	3.2
20	4.43	94%	5	0.59	0.56	3.9	4.29	94%	5	0.59	0.55	3.8
21	3.46	94%	5	0.59	0.48	3.1	3.35	94%	5	0.59	0.47	3.0
22	2.95	93%	5	0.59	0.44	2.7	2.86	93%	5	0.59	0.43	2.6
23	2.61	93%	5	0.59	0.42	2.4	2.52	93%	5	0.59	0.41	2.3
24	2.33	93%	3	0.35	0.31	2.1	2.25	93%	3	0.35	0.30	2.0
25	2.18	93%	3	0.35	0.30	2.0	2.10	93%	3	0.35	0.29	1.9
26	3.96	94%	5	0.59	0.52	3.5	3.84	94%	5	0.59	0.51	3.4
27	3.22	93%	5	0.59	0.46	2.9	3.11	93%	5	0.59	0.45	2.8
28	3.88	94%	5	0.59	0.52	3.5	3.76	94%	5	0.59	0.50	3.4
29	3.17	93%	5	0.59	0.46	2.9	3.06	93%	5	0.59	0.45	2.8
30	8.55	95%	7.5	0.74	0.74	7.3	8.28	95%	7.5	0.74	0.74	7.1
31	5.55	94%	7.5	0.74	0.63	4.9	5.36	94%	7.5	0.74	0.62	4.7
32	10.63	95%	15	1.23	1.02	9.1	10.29	95%	15	1.23	1.00	8.8
33	7.28	95%	15	1.23	0.85	6.4	7.04	95%	15	1.23	0.84	6.2
34	13.95	95%	15	1.23	1.21	11.8	13.52	95%	15	1.23	1.19	11.5
35	8.40	95%	15	1.23	0.90	7.3	8.12	95%	15	1.23	0.88	7.1
36	5.56	94%	7.5	0.74	0.63	4.9	5.38	94%	7.5	0.74	0.62	4.7
37	4.30	94%	7.5	0.74	0.55	3.8	4.15	94%	7.5	0.74	0.54	3.7
38	8.36	95%	15	1.23	0.89	7.3	8.10	95%	15	1.23	0.88	7.0
39	6.27	94%	15	1.23	0.81	5.6	6.06	94%	15	1.23	0.80	5.4
40	9.48	95%	15	1.23	0.95	8.2	9.19	95%	15	1.23	0.94	7.9
41	6.77	95%	15	1.23	0.83	6.0	6.54	94%	15	1.23	0.82	5.8
42	5.58	94%	5	0.59	0.59	4.9	5.41	94%	5	0.59	0.59	4.7
43	4.45	94%	5	0.59	0.56	4.0	4.30	94%	5	0.59	0.55	3.8
44	8.02	95%	7.5	0.74	0.74	6.9	7.77	95%	7.5	0.74	0.74	6.7
45	5.58	94%	7.5	0.74	0.63	4.9	5.39	94%	7.5	0.74	0.62	4.7
46	19.23	95%	15	1.23	1.23	16.0	18.63	95%	15	1.23	1.23	15.5
47	14.59	95%	15	1.23	1.23	12.3	14.10	95%	15	1.23	1.22	12.0
48	12.69	95%	15	1.23	1.14	10.8	12.27	95%	15	1.23	1.11	10.5
49	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
50	5.80	94%	10	0.91	0.67	5.1	5.61	94%	10	0.91	0.66	4.9
51	11.46	95%	10	0.91	0.91	9.7	11.10	95%	10	0.91	0.91	9.4
52	5.80	94%	7.5	0.74	0.65	5.1	5.61	94%	7.5	0.74	0.63	4.9
53	9.11	95%	7.5	0.74	0.74	7.7	8.82	95%	7.5	0.74	0.74	7.5
54	5.80	94%	5	0.59	0.59	5.0	5.61	94%	5	0.59	0.59	4.9
55	7.78	95%	5	0.59	0.59	6.6	7.54	95%	5	0.59	0.59	6.4
56	5.80	94%	5	0.59	0.59	5.0	5.61	94%	5	0.59	0.59	4.9
57	6.65	95%	5	0.59	0.59	5.7	6.44	94%	5	0.59	0.59	5.5
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.03	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A

	Minimally Compliant Fan at Design Point, EL3						Minimally Compliant Fan at Design Point, EL4					
	FAN	Default Transmission	Default Motor			FEP	FAN	Default Transmission	Default Motor			FEP
	Max BHP @ Design Point	Transmission Efficiency at Design Point	Motor HP	Full Load Losses	Losses at Design Point (hp)	FEP_EL3 (kW)	Max BHP @ Design Point	Transmission Efficiency at Design Point	Motor HP	Full Load Losses	Losses at Design Point (hp)	FEP_EL4 (kW)
18	4.68	94%	5	0.59	0.58	4.1	4.54	94%	5	0.59	0.57	4.0
19	3.48	94%	5	0.59	0.48	3.1	3.37	94%	5	0.59	0.47	3.0
20	4.16	94%	5	0.59	0.54	3.7	4.04	94%	5	0.59	0.53	3.6
21	3.24	93%	5	0.59	0.46	2.9	3.14	93%	5	0.59	0.45	2.8
22	2.77	93%	5	0.59	0.43	2.5	2.69	93%	5	0.59	0.42	2.5
23	2.44	93%	5	0.59	0.41	2.3	2.37	93%	5	0.59	0.40	2.2
24	2.18	93%	3	0.35	0.30	2.0	2.12	93%	3	0.35	0.29	1.9
25	2.04	93%	3	0.35	0.29	1.9	1.97	92%	3	0.35	0.28	1.8
26	3.72	94%	5	0.59	0.50	3.3	3.61	94%	5	0.59	0.49	3.2
27	3.01	93%	5	0.59	0.44	2.7	2.92	93%	5	0.59	0.44	2.7
28	3.64	94%	5	0.59	0.50	3.3	3.54	94%	5	0.59	0.49	3.2
29	2.97	93%	5	0.59	0.44	2.7	2.87	93%	5	0.59	0.43	2.6
30	8.03	95%	7.5	0.74	0.74	6.9	7.80	95%	7.5	0.74	0.74	6.7
31	5.19	94%	7.5	0.74	0.60	4.6	5.03	94%	7.5	0.74	0.59	4.4
32	9.98	95%	15	1.23	0.98	8.6	9.69	95%	15	1.23	0.96	8.3
33	6.81	95%	15	1.23	0.83	6.0	6.60	94%	15	1.23	0.82	5.8
34	13.11	95%	15	1.23	1.16	11.1	12.72	95%	15	1.23	1.14	10.8
35	7.86	95%	15	1.23	0.87	6.8	7.62	95%	15	1.23	0.86	6.6
36	5.22	94%	7.5	0.74	0.61	4.6	5.07	94%	7.5	0.74	0.60	4.5
37	4.02	94%	7.5	0.74	0.53	3.6	3.90	94%	7.5	0.74	0.52	3.5
38	7.86	95%	15	1.23	0.87	6.8	7.63	95%	15	1.23	0.86	6.7
39	5.86	94%	15	1.23	0.79	5.2	5.68	94%	15	1.23	0.79	5.1
40	8.91	95%	15	1.23	0.92	7.7	8.65	95%	15	1.23	0.91	7.5
41	6.33	94%	15	1.23	0.81	5.6	6.13	94%	15	1.23	0.80	5.4
42	5.25	94%	5	0.59	0.59	4.6	5.09	94%	5	0.59	0.59	4.5
43	4.16	94%	5	0.59	0.54	3.7	4.03	94%	5	0.59	0.53	3.6
44	7.53	95%	7.5	0.74	0.74	6.5	7.31	95%	7.5	0.74	0.74	6.3
45	5.22	94%	7.5	0.74	0.61	4.6	5.05	94%	7.5	0.74	0.60	4.4
46	18.06	95%	15	1.23	1.23	15.0	17.53	95%	15	1.23	1.23	14.6
47	13.65	95%	15	1.23	1.20	11.6	13.22	95%	15	1.23	1.17	11.2
48	11.87	95%	15	1.23	1.09	10.1	11.50	95%	15	1.23	1.07	9.8
49	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
50	5.42	94%	10	0.91	0.65	4.8	5.25	94%	10	0.91	0.64	4.6
51	10.77	95%	10	0.91	0.91	9.1	10.45	95%	10	0.91	0.91	8.9
52	5.42	94%	7.5	0.74	0.62	4.8	5.25	94%	7.5	0.74	0.61	4.6
53	8.56	95%	7.5	0.74	0.74	7.3	8.31	95%	7.5	0.74	0.74	7.1
54	5.42	94%	5	0.59	0.59	4.7	5.25	94%	5	0.59	0.59	4.6
55	7.31	95%	5	0.59	0.59	6.2	7.09	95%	5	0.59	0.59	6.0
56	5.42	94%	5	0.59	0.59	4.7	5.25	94%	5	0.59	0.59	4.6
57	6.25	94%	5	0.59	0.59	5.4	6.07	94%	5	0.59	0.59	5.2
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A
	0.02	73%	#N/A	#N/A	#N/A	#N/A	0.02	73%	#N/A	#N/A	#N/A	#N/A

	Minimally Compliant Fan at Design Point, EL5						Minimally Compliant Fan at Design Point, EL6					
	FAN	Default Transmission	Default Motor			FEP	FAN	Default Transmission	Default Motor			FEP
	Max BHP @ Design Point	Transmission Efficiency at Design Point	Motor HP	Full Load Losses	Losses at Design Point (hp)	FEP_EL5 (kW)	Max BHP @ Design Point	Transmission Efficiency at Design Point	Motor HP	Full Load Losses	Losses at Design Point (hp)	FEP_EL6 (kW)
18	2.78	93%	5	0.59	0.43	2.5	4.29	94%	5	0.59	0.55	3.8
19	3.27	93%	5	0.59	0.46	3.0	3.17	93%	5	0.59	0.46	2.9
20	2.41	93%	5	0.59	0.40	2.2	3.81	94%	5	0.59	0.51	3.4
21	3.04	93%	5	0.59	0.45	2.8	2.95	93%	5	0.59	0.44	2.7
22	1.46	92%	5	0.59	0.36	1.5	2.54	93%	5	0.59	0.41	2.3
23	2.29	93%	5	0.59	0.40	2.1	2.23	93%	5	0.59	0.39	2.1
24	#VALUE!	#VALUE!	3	0.35	#VALUE!	#VALUE!	2.00	93%	3	0.35	0.28	1.8
25	1.91	92%	3	0.35	0.28	1.7	1.86	92%	3	0.35	0.27	1.7
26	#REF!	#REF!	5	0.59	#REF!	#REF!	3.41	94%	5	0.59	0.48	3.1
27	2.83	93%	5	0.59	0.43	2.6	2.74	93%	5	0.59	0.43	2.5
28	13.51	95%	5	0.59	0.59	11.0	3.34	94%	5	0.59	0.47	3.0
29	2.79	93%	5	0.59	0.43	2.5	2.70	93%	5	0.59	0.42	2.5
30	33.10	96%	7.5	0.74	0.74	26.4	7.36	95%	7.5	0.74	0.74	6.4
31	4.88	94%	7.5	0.74	0.58	4.3	4.73	94%	7.5	0.74	0.57	4.2
32	37.39	96%	15	1.23	1.23	30.1	9.15	95%	15	1.23	0.93	7.9
33	6.40	94%	15	1.23	0.81	5.7	6.21	94%	15	1.23	0.81	5.5
34	32.33	96%	15	1.23	1.23	26.1	12.02	95%	15	1.23	1.10	10.2
35	7.39	95%	15	1.23	0.85	6.5	7.17	95%	15	1.23	0.84	6.3
36	76.93	96%	7.5	0.74	0.74	60.4	4.79	94%	7.5	0.74	0.58	4.2
37	3.78	94%	7.5	0.74	0.52	3.4	3.67	94%	7.5	0.74	0.51	3.3
38	#REF!	#REF!	15	1.23	#REF!	#REF!	7.20	95%	15	1.23	0.84	6.3
39	5.51	94%	15	1.23	0.78	4.9	5.34	94%	15	1.23	0.78	4.8
40	#REF!	#REF!	15	1.23	#REF!	#REF!	8.17	95%	15	1.23	0.89	7.1
41	5.95	94%	15	1.23	0.80	5.3	5.77	94%	15	1.23	0.79	5.2
42	#REF!	#REF!	5	0.59	#REF!	#REF!	4.81	94%	5	0.59	0.59	4.3
43	3.91	94%	5	0.59	0.52	3.5	3.80	94%	5	0.59	0.51	3.4
44	#REF!	#REF!	7.5	0.74	#REF!	#REF!	6.90	95%	7.5	0.74	0.73	6.0
45	4.90	94%	7.5	0.74	0.59	4.3	4.76	94%	7.5	0.74	0.58	4.2
46	112.66	96%	15	1.23	1.23	88.5	16.56	95%	15	1.23	1.23	13.9
47	12.82	95%	15	1.23	1.15	10.9	12.44	95%	15	1.23	1.12	10.6
48	11.16	95%	15	1.23	1.05	9.5	10.83	95%	15	1.23	1.03	9.3
49	0.00	47%	#N/A	#N/A	#N/A	#N/A	0.02	72%	#N/A	#N/A	#N/A	#N/A
50	5.10	94%	10	0.91	0.63	4.5	4.95	94%	10	0.91	0.63	4.4
51	105.85	96%	10	0.91	0.91	83.0	9.87	95%	10	0.91	0.91	8.4
52	5.10	94%	7.5	0.74	0.60	4.5	4.95	94%	7.5	0.74	0.59	4.4
53	34.68	96%	7.5	0.74	0.74	27.6	7.84	95%	7.5	0.74	0.74	6.7
54	5.10	94%	5	0.59	0.59	4.5	4.95	94%	5	0.59	0.59	4.4
55	53.78	96%	5	0.59	0.59	42.3	6.70	95%	5	0.59	0.59	5.7
56	5.10	94%	5	0.59	0.59	4.5	4.95	94%	5	0.59	0.59	4.4
57	105.13	96%	5	0.59	0.59	82.2	5.73	94%	5	0.59	0.59	5.0
	0.00	45%	#N/A	#N/A	#N/A	#N/A	0.02	72%	#N/A	#N/A	#N/A	#N/A
	0.00	0%	#N/A	#N/A	#DIV/0!	#DIV/0!	0.02	72%	#N/A	#N/A	#N/A	#N/A
	0.00	42%	#N/A	#N/A	#N/A	#N/A	0.02	72%	#N/A	#N/A	#N/A	#N/A
	0.00	0%	#N/A	#N/A	#DIV/0!	#DIV/0!	0.02	72%	#N/A	#N/A	#N/A	#N/A
	0.00	41%	#N/A	#N/A	#N/A	#N/A	0.02	72%	#N/A	#N/A	#N/A	#N/A
	0.00	0%	#N/A	#N/A	#DIV/0!	#DIV/0!	0.02	72%	#N/A	#N/A	#N/A	#N/A
	0.00	39%	#N/A	#N/A	#N/A	#N/A	0.02	72%	#N/A	#N/A	#N/A	#N/A
	0.00	0%	#N/A	#N/A	#DIV/0!	#DIV/0!	0.02	72%	#N/A	#N/A	#N/A	#N/A

	FEP_fan and FEP_STD								EVEL COMPARISON AT THE CONSIDERED I					
	FEP (kW)								"Pass/Fail"					
	FEP (fan)	FEP (EL1)	FEP (EL2)	FEP (EL3)	FEP (EL4)	FEP (EL5)	FEP (EL6)	FEI (based on EL3)	EL1	EL2	EL3	EL4	EL5	EL6
18	2.91	4.38	4.26	4.15	4.03	2.54	3.82	1.42	PASS	PASS	PASS	PASS	FAIL	PASS
19	2.91	3.34	3.23	3.13	3.04	2.96	2.87	1.08	PASS	PASS	PASS	PASS	PASS	FAIL
20	2.83	3.94	3.82	3.71	3.61	2.23	3.42	1.31	PASS	PASS	PASS	PASS	FAIL	PASS
21	2.83	3.12	3.02	2.93	2.84	2.76	2.69	1.04	PASS	PASS	PASS	PASS	FAIL	FAIL
22	2.91	2.69	2.61	2.54	2.47	1.46	2.34	0.87	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
23	2.91	2.40	2.33	2.26	2.20	2.14	2.09	0.78	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
24	1.92	2.10	2.04	1.98	1.93	#VALUE!	1.83	1.03	PASS	PASS	PASS	PASS	#VALUE!	FAIL
25	1.92	1.97	1.91	1.85	1.80	1.75	1.70	0.97	PASS	FAIL	FAIL	FAIL	FAIL	FAIL
26	2.89	3.54	3.44	3.34	3.25	#REF!	3.08	1.16	PASS	PASS	PASS	PASS	#REF!	PASS
27	2.89	2.91	2.82	2.74	2.66	2.58	2.52	0.95	PASS	FAIL	FAIL	FAIL	FAIL	FAIL
28	2.90	3.47	3.37	3.27	3.18	11.03	3.01	1.13	PASS	PASS	PASS	PASS	PASS	PASS
29	2.90	2.87	2.78	2.70	2.62	2.55	2.48	0.93	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
30	4.94	7.28	7.08	6.88	6.70	26.37	6.36	1.39	PASS	PASS	PASS	PASS	PASS	PASS
31	4.94	4.86	4.71	4.56	4.43	4.30	4.18	0.92	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
32	7.28	9.10	8.83	8.57	8.33	30.07	7.89	1.18	PASS	PASS	PASS	PASS	PASS	PASS
33	7.28	6.37	6.17	5.99	5.82	5.66	5.51	0.82	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
34	9.50	11.84	11.48	11.14	10.83	26.13	10.24	1.17	PASS	PASS	PASS	PASS	PASS	PASS
35	9.50	7.28	7.06	6.84	6.64	6.46	6.28	0.72	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
36	4.60	4.87	4.72	4.59	4.46	60.41	4.23	1.00	PASS	PASS	FAIL	FAIL	PASS	FAIL
37	4.60	3.82	3.70	3.59	3.49	3.39	3.30	0.78	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
38	7.01	7.25	7.04	6.84	6.65	#REF!	6.31	0.98	PASS	PASS	FAIL	FAIL	#REF!	FAIL
39	7.01	5.55	5.38	5.23	5.08	4.94	4.81	0.75	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
40	8.98	8.17	7.92	7.70	7.48	#REF!	7.09	0.86	FAIL	FAIL	FAIL	FAIL	#REF!	FAIL
41	8.98	5.96	5.77	5.60	5.44	5.29	5.15	0.62	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
42	3.03	4.86	4.72	4.59	4.47	#REF!	4.25	1.51	PASS	PASS	PASS	PASS	#REF!	PASS
43	3.03	3.95	3.83	3.71	3.60	3.50	3.40	1.22	PASS	PASS	PASS	PASS	PASS	PASS
44	4.91	6.87	6.67	6.49	6.32	#REF!	5.99	1.32	PASS	PASS	PASS	PASS	#REF!	PASS
45	4.91	4.88	4.73	4.58	4.45	4.32	4.20	0.93	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
46	9.75	15.96	15.49	15.05	14.64	88.54	13.88	1.54	PASS	PASS	PASS	PASS	PASS	PASS
47	9.75	12.35	11.96	11.59	11.24	10.91	10.60	1.19	PASS	PASS	PASS	PASS	PASS	PASS
48	9.75	10.80	10.45	10.13	9.82	9.54	9.27	1.04	PASS	PASS	PASS	PASS	FAIL	FAIL
49	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	####	####	####	####	#N/A	####
50	6.00	5.08	4.93	4.78	4.64	4.51	4.39	0.80	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
51	6.00	9.67	9.39	9.13	8.88	83.00	8.43	1.52	PASS	PASS	PASS	PASS	PASS	PASS
52	5.08	5.07	4.91	4.76	4.62	4.48	4.36	0.94	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
53	5.08	7.72	7.50	7.29	7.09	27.60	6.73	1.44	PASS	PASS	PASS	PASS	PASS	PASS
54	3.51	5.02	4.87	4.73	4.60	4.47	4.36	1.35	PASS	PASS	PASS	PASS	PASS	PASS
55	3.51	6.57	6.38	6.20	6.03	42.32	5.72	1.76	PASS	PASS	PASS	PASS	PASS	PASS
56	2.42	5.02	4.87	4.73	4.60	4.47	4.36	1.96	PASS	PASS	PASS	PASS	PASS	PASS
57	2.42	5.69	5.53	5.37	5.23	82.21	4.97	2.22	PASS	PASS	PASS	PASS	PASS	PASS
	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	####	####	####	####	#N/A	####
	#N/A	#N/A	#N/A	#N/A	#N/A	#DIV/0!	#N/A	#N/A	####	####	####	####	#N/A	####
	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	####	####	####	####	#N/A	####
	#N/A	#N/A	#N/A	#N/A	#N/A	#DIV/0!	#N/A	#N/A	####	####	####	####	#N/A	####
	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	####	####	####	####	#N/A	####
	#N/A	#N/A	#N/A	#N/A	#N/A	#DIV/0!	#N/A	#N/A	####	####	####	####	#N/A	####
	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	####	####	####	####	#N/A	####
	#N/A	#N/A	#N/A	#N/A	#N/A	#DIV/0!	#N/A	#N/A	####	####	####	####	#N/A	####

DO NOT DELETE (Drop Down Lists)

Axial Cyclindrical Housed
Panel
Centrifugal Housed
Centrifugal Unhoused
Inline and Mixed Flow
PRV
Radial